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electronics today INTERNATIONAL

DECEMBER 1983 90p

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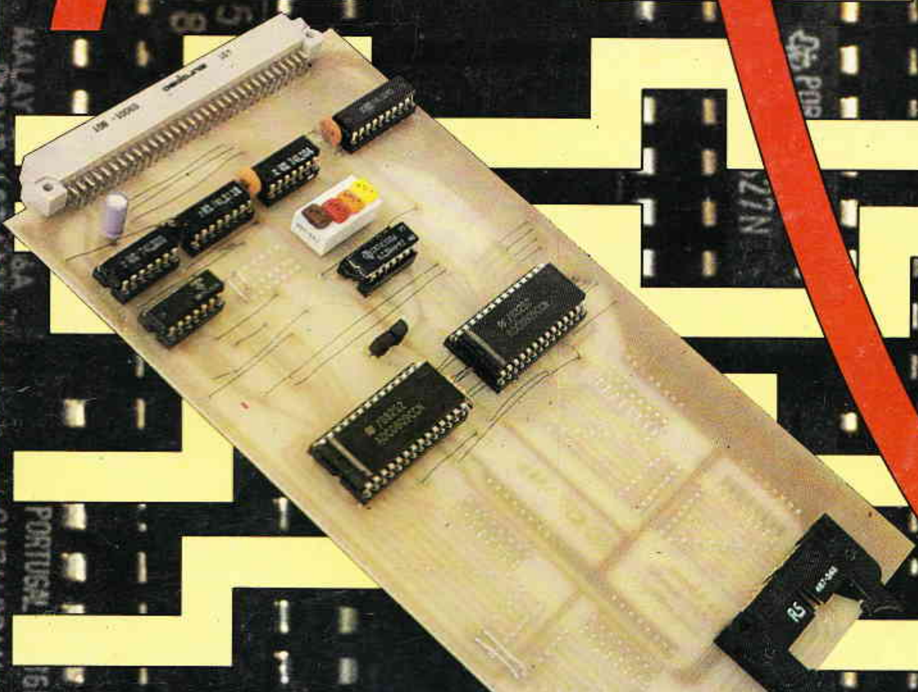
20P



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Lightsaver–neat device to save your light bulbs

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Stereo Mixer — this is a really
tile new mixer that enables the
tructor DJ to produce a profes-
l performance every time. There
wo stereo inputs for magnetic cart-
s, a stereo auxiliary input and mike
Other 'plus' features are auto-
ing for fast or slow slider controls,
-mixing, ducking, interrupt, input
ulation, in short everything . . . the
e works — AND — under £100 complete! Complete kit **£97.50** + VAT

TRANSCENDENT 2000 — Although only a 3 octave keyboard the '2000' features the same design ingenuity, careful engineering and quality components of its larger brethren. The kit is well within the scope of the first time builder — buy it, build it — play it! You will know you have made the right choice.
Complete kit **£165.00** + VAT

BIG NEWS ABOUT OUR LATEST ADVANCES IN ROBOTICS SEE INSIDE BACK COVER

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versatile modular mixer, featured as a constructional article in Practical Electronics
be built up to a maximum of 24 inputs, 4 outputs and an auxiliary channel. Each input
nnel has Mic and Line inputs, variable gain, bass and treble controls and a para-
ic middle frequency equalizer. There are send and return jacks, auxiliary, pan and
r controls and output and group switching. The output channels have PPM displays
record and studio outputs. The auxiliary channel also has a PPM display and there is
adphone monitor jack and a built-in talk-back microphone. The mixer modules plug
base units each of which takes up to 6 channels. To eliminate hum, the power supply
a separate cabinet.

Digital Delay Line — With its ability to give delay times from 1.6 mSecs to up to 1.6 secs. Many powerful effects including phasing, flanging, A.D.T., chorus, echo &

vibrato are obtained. The basic kit is extended in 400 mS steps up to 1.6 secs. Simply by adding more parts to the PCB. Compare with units costing over £1,000!
Complete kit (400 mS delay) **£130** + VAT
Parts for extra 400 mS delay **£9.50** + VAT

KIT PRICES

ut channel	£19.90	Base unit and wooden front	£27.50
put channel	£18.50	Pair of mahogany end cheeks	£12.50
iliary channel	£22.50	Power Supply and cabinet	£19.50
k Panel	£3.00		

All prices are VAT exclusive

Free Soldering Practise Kit on request with your first kit — useful tips, well illustrated.

ANSCENDENT POLYSYNTH — A four octave poly-
nic synthesiser with outstanding design characteristics
versatility and performance to match.
omplete kit **£230.00** plus VAT (single voice)
a voice (up to three more) **£35.60** plus VAT

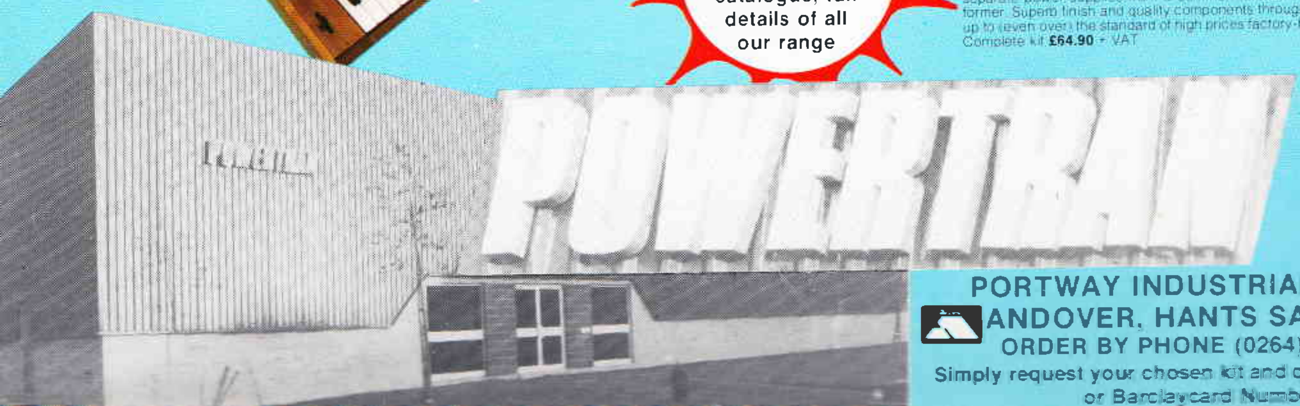
MPA 200 — is a low price high power 100W amplifier its smart styling, professional appearance and performance make it one of our most popular designs. With adaptable inputs the mixer accepts a variety of sources yet straightforward construction makes it ideal for the first time builder. Complete kit **£49.90** + VAT

Chromatheque 5000 — a 5 channel lighting system powerful enough for professional discos yet controllable for home-effects. Sound to light, strobe to music level, random or sequential effects — each channel can handle up to 500W yet minimal wiring is needed with our unique single board design. Complete kit **£49.50** + VAT

ETI VOCODER — 14 channels, each with independent level control for maximum versatility and intelligibility. Two input amplifiers — for speech/excitation — each with level control and tone control. The vocoder is a powerful yet flexible machine that is interesting to build and thanks to our easy to follow construction manual, is within the capability of most enthusiasts. Complete kit **£175.00** + VAT

SP2 200 twice the power with two of the reliable, durable and economic amps from the MPA 200, fed by separate power supplies from a common toroidal transformer. Superb finish and quality components throughout — up to (even over) the standard of high prices factory-built units! Complete kit **£64.90** + VAT

Component packs for most kits are available See our great free catalogue, full details of all our range



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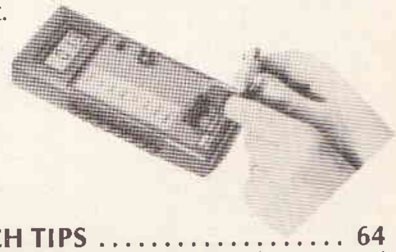
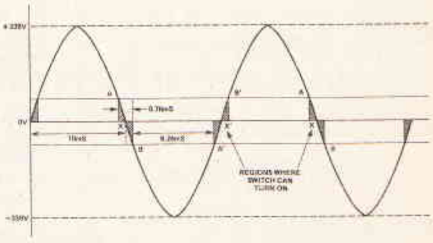
FEATURES



Due to pressure of space, IC Update has been held over until next month.

PROJECTS



INFORMATION

74 SERIES

7400	25p
7401	25p
7402	25p
7403	25p
7404	25p
7405	30p
7406	90p
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7408	25p
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7411	25p
7412	25p
7413	40p
7414	60p
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7428	30p
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74365A	48p
74366A	48p
74367A	48p
74368A	48p
74376	100p
74390	90p
74393	150p
74490	120p

74LS SERIES

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74LS03	20p
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74LS645	200p
74LS645-1	250p
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74LS669	70p
74LS670	120p
74LS674	550p
74LS682	250p
74LS684	400p
74LS687	450p

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74S00	30p
74S02	30p
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74S05	60p
74S08	60p
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74S85	450p
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74C174	90p
74C175	90p
74C192	100p
74C193	115p
74C194	120p
74C195	100p
74C221	150p
74C244	160p
74C245	180
74C373	160p
74C374	160p
74C902	70p
74C911	750p
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74ALS10	35p
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74ALS74	50p
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40174	50p
40175	75p
40193	75p
40244	160p
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CA3086	48p
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CA3090AQ	375p
CA3130E	90p
CA3130T	110p
CA3140E	40p
CA3140T	90p
CA3160E	100p
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ICL7611	95p
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ICM7217	750p
ICM7555	90p
ICM7556	140p
LC7120	300p
LC7130	325p
LC7137	270p
LF347	150p
LF351	48p
LF353	95p
LF356P	90p
LF357	110p
LF13331	350p
LM10C	325p
LM301A	25p
LM307	50p
LM308N	75p
LM310	120p
LM311	70p
LM318	150p
LM319	215p
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LM324	30p
LM334Z	90p
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LM339	40p
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LM1011	480p
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LM1830	250p
LM1871	300p
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LM3914	200p
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LM13600	110p
M51513L	230p
M51516L	500p
MB3712	200p
MB3730	400p
MC1310P	150p
MC1413	75p
MC1458	36p
MC1483	100p
MC1495L	350p
MC1496	70p
MC3340P	120p
MC3401	50p
MC3403	60p
MF10CN	320p
MK50240	900p
MK50398	700p
ML920	800p
MM57160	620p
MM6221A	600p
NE531	140p
NE544	150p
NE555	16p
NE556	45p
NE564	420p
NE565	120p
NE566	155p
NE567	140p
NE570	410p
NE571	400p
NE592	60p
NE5532	130p
NE5533	140p
NE5534P	110p
NE5534AP	125p
PLL02A	500p
RC4136	60p
S566B	225p
SAA1900	£16
SAD1024A	
SFF96364	800p
SN76488	450p
SN76489	480p
SN76495	400p
SP0256AL	£10
TA7120	150p
TA7130	160p
TA7204	150p
TA7205	90p
TA7222	150p
TA7310	150p
TBA231	120p
TBA800	80p
TBA810	100p
TBA820	80p
TBA950	225p
TC9109	750p
TCA210	250p
TCA220	250p
TCA270	350p
TCA940	175p
TCA965	120p
TDA1004A	£3
TDA1008	320p
TDA1010	200p
TDA1022	500p
TDA1024	120p
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TDA2002	325p
TDA2003	325p
TDA2006	350p
TDA2020	320p
TDA7000	350p
TL064	95p
TL071/81	25p
TL072/82	45p
TL074	100p
TL083	75p
TL084	90p
TL094	200p
TL170	50p
TL430C	70p
UA1003-3	935p
UA2240	120p
UAA170	170p
ULN2003A	75p
ULN2004	75p
ULN2068	290p
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ULN2803	150p
ULN2804	150p
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15V	7815	40p	7915	45p
18V	7818	40p	7918	45p
24V	7824	40p	7924	45p
5V 100mA	78L05	30p	79L05	45p
6V 100mA	78L06	30p		
8V 100mA	78L08	30p		
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8155	350p
8156	350p
8205	225p
8212	110p
8216	100p
8224	110p
8226	250p
8228	270p
8243	280p
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DS8880	170p
LF13201	450p
MC1488	55p
MC1489	55p
MC3418	950p
MC3446	250p
MC3459	450p
MC3470	650p
MC3480	850p
MC3486	500p
MC3487	300p
MC4024	325p
MC4044	325p
MC14411	675p
MC14412	750p
75107	90p
75110/12	160p
75114/15	160p
75121/22	140p
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75154	140p
75159	220p
75365	150p
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75491/2	65p
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8T28	120p
8T95/96	90p
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81LS95/96	120p
81LS97/98	120p
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COM8116	800p
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IM6402	360p
TR1602	300p

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(TEXTOOL)

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100KHz	325p
200KHz	325p
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1.0	325p
1.008	275p
1.8432	300p
2.00	250p
2.45760	210p
2.5	250p
2.662	250p
3.276	150p
3.5795	120p
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4.00	150p
4.194	200p
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4.608	250p
4.915	250p
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7.0	150p
7.168	175p
8.00	175p
8.86	175p
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10.5	250p
10.7	200p
12.00	150p
14.318	175p
14.756	250p
15.00	200p
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BC107/8	13p
BC109C	14p
BC169C	12p
BC172	12p
BC177/8	17p
BC179	18p
BC182/3	10p
BC184	11p
BC187	30p
BC212/3	11p
BC214	12p
BC237	15p
BC327	16p
BC337	16p
BC338	16p
BC461	25p
BC477/8	30p
BC516/7	40p
BC547B	14p
BC548C	12p
BC549C	16p
BC557B	14p
BC559C	16p
BCY70	18p
BCY71	22p
BD131	75p
BD132	80p
BD135/6	40p
BD139	40p
BD140	40p
BD189	60p
BD232	60p
BD233	75p
BD235	85p
BD241	60p
BD242	60p
BD379	60p
BD380	60p
BD677	40p
BF244B	35p
BF256B	50p
BF257/8	32p
BF337	30p
BF339	25p
BFR40/1	25p
BFR79	25p
BFR80/1	25p
BFR98	180p
BFX29	40p
BFX30	27p
BFX84/5	40p
BFX86/7	27p
BFX88	27p
BFX89	180p
BFY50	24p
BFY51/2	24p
BFY56	33p
BFY90	80p
BRY39	45p
BSX19/20	24p
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BU108	250p
BU109	225p
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BU180A	120p
BU205	200p
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BU406	145p
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MPF103/4	30p
MPF105	30p
MPSA06	30p
MPSA12	50p
MPSA13	50p
MPSA20	50p
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MPSA43	50p
MPSA56	32p
MPSA70	50p
MPSA93	40p
MPSU06	63p
MPSU07	60p
MPSU45	90p
MPSU65	78p
TIP29A	35p
TIP29C	40p
TIP30A	35p
TIP30C	40p
TIP31A	40p
TIP31C	45p
TIP32A	45p
TIP32C	40p
TIP33A	70p
TIP33C	80p
TIP34A	90p
TIP34C	120p
TIP35A	120p
TIP35C	140p
TIP36A	140p
TIP36C	150p
TIP41A	50p
TIP41C	55p
TIP42A	60p
TIP42C	65p
TIP54	160p
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TIP121	75p
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2N698	45p
2N706A	30p
2N708	30p
2N918	45p
2N930	18p
2N1131/2	36p
2N1613	25p
2N1711	25p
2N2102	70p
2N2160	350p
2N2219A	25p
2N2222A	25p
2N2369A	17p
2N2484	25p
2N2646	40p
2N2904/5	25p
2N2906A	25p
2N2907A	25p
2N2926	9p
2N3053	25p
2N3054	55p
2N3055	35p
2N3442	140p
2N3553	240p
2N3584	250p
2N3643/4	48p
2N3702/3	10p
2N3704/5	10p
2N3706/7	10p
2N3708	10p
2N3773	200p
2N3819	20p
2N3823	30p
2N3866	90p
2N3902	700p
2N3904	15p
2N3906	16p
2N4037	65p
2N4056	65p
2N4123/4	27p
2N4125/6	27p
2N4401/3	25p
2N4427	90p
2N4871	50p
2N5087	27p
2N5089	27p
2N5172	27p
2N5191	90p
2N5245	40p
2N5401	60p
2N5459	30p
2N5460	60p
2N5485	36p
2N5875	250p
2N6027	30p
2N6052	300p
2N6059	325p
2N6107	65p
2N6247	190p
2N6254	130p
2N6290	65p
2SC1306	100p
2SC1307	150p
2SC1957	90p
2SC1969	150p
2SC2028	80p
2SC2029	200p
2SC2078	160p
2SC2335	200p
2SC2612	200p
3N128	120p
3N140	120p
3N141	110p
3N201	110p
3N204	200p
40290	250p
40361/2	75p
40408	90p
40409	100p
40410	100p
40594	120p
40595	120p
40673	75p
40871/2	100p

DIODES

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BYX36300	20p
OA47	8p
OA90/91	9p
OA95	9p
OA200	9p
OA202	10p
1N914	4p
1N916	7p
1N4148	4p
1N4001/2	5p
1N4003/4	6p
1N4005	6p
1N4006/7	7p
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1N5404/5	14p
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2A	400V	45p
3A	200V	60p
3A	600V	72p
4A	100V	95p
4A	400V	100p
6A	50V	80p
6A	100V	100p
6A	400V	120p
10A	400V	200p
25A	400V	400p

TRIACS PLASTIC

3A 400V	60p
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6A 500V	88p
8A 400V	75p
8A 500V	95p
12A 400V	85p
12A 500V	105p
16A 400V	110p
16A 500V	130p
T2800D	130p
TIC 206D	60p
TIC 226D	75p
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556CMOS	150	ICL7611	95	▶LM380	75	MC1496	68	▶RC4136	55	▶TL081	25
709	25	ICL7621	180	▶LM381	120	MC3340	135	▶RC4558	40	TL082	45
▶741	14	ICL7622	180	LM382	120	▶MF10CN	350	SL480	170	TL084	90
748	35	ICL8038	295	LM384	130	ML922	400	SL490	250	TL170	50
9400CJ	350	ICL8211A	200	LM386	90	ML924	195	SL76018	150	UA2240	120
AY-3-1270	720	ICM7224	785	LM387	120	ML925	210	▶SN76477	380	ULN2003	70
AY-3-8910	370	ICM7555	80	LM393	40	ML926	140	SP8629	250	ULN2004	70
AY-3-8912	540	▶LF351	45	LM709	25	ML927	140	TBA120S	70	XR2206	290
CA3046	60	LF353	85	LM711	60	ML928	140	TBA800	75	ZN414	80
▶CA3080	65	LF356	90	LM725	350	ML929	140	TBA810	96	ZN423	135
CA3089	190	LM10	325	LM733	75	MM5387A	465	TBA820	70	ZN424	135
CA3090AQ	375	LM301A	25	LM741	14	NE529	225	TBA950	220	ZN425E	350
CA3130E	85	LM311	50	LM747	60	NE531	140	TDA1008	320	ZN426E	300
▶CA3140E	36	LM318	120	LM1458	40	NE544	205	▶TDA1022	490	ZN427E	600
CA3161E	100	LM324	30	LM2917	200	▶NE555	16	TDA1024	125	ZN428E	410
CA3189	290	LM334Z	100	LM3900	45	▶NE556	45	TL061	40	ZN459	285
▶CA3240E	100	LM335Z	125	▶LM3909	75	NE565	110	TL062	60	ZN1034E	200

TRANSISTORS

				BC517	40	BF337	40	MPSU56	60	ZTX108	10	2N3055	50
				BC547	7	BFR40	23	TIP29A	30	ZTX109	12	2N3442	120
				BC548	10	BFR80	23	TIP29B	55	ZTX300	14	▶2N3702	8
AC126	30	BC149	9	BC549	10	▶BFR81	20	TIP29C	37	ZTX301	16	2N3703	9
AC127	30	BC157	8	BC558	10	BFX29	25	TIP30A	35	ZTX302	15	▶2N3704	8
AC128	30	BC158	10	BCY70	18	BFX84	25	TIP30B	50	ZTX304	17	2N3705	9
▶AC128	20	BC159	8	BCY71	18	BFX85	25	TIP30C	37	ZTX341	30	2N3706	9
AC176	25	BC160	45	BCY72	18	BFX86	28	TIP31A	35	ZTX500	15	2N3707	10
AC187	22	BC168C	10	BD115	55	BFX87	25	TIP31C	37	ZTX501	15	2N3708	10
AC188	22	BC169C	10	BD131	35	BFX88	25	TIP32A	35	ZTX502	15	2N3709	10
AD142	120	BC170	8	BD132	35	BFY50	23	TIP32C	37	ZTX503	18	2N3772	170
AD149	80	BC171	10	BD133	50	BFY51	20	TIP33A	50	ZTX504	25	▶2N3773	195
AD161	40	BC172	8	BD135	40	BFY52	23	TIP33C	75	2N697	20	▶2N3819	20
AD162	40	BC177	18	BD136	30	BFY53	32	TIP34A	60	2N698	40	2N3820	40
AF124	60	BC178	18	BD137	30	BFY55	32	TIP34C	85	2N706A	20	2N3823	65
AF126	50	BC179	18	BD138	30	BFY56	32	TIP35A	105	2N708	20	2N3866	90
AF139	40	BC182	10	▶BD139	35	BRY39	40	TIP35C	125	2N918	35	2N3903	10
AF186	70	▶BC182L	8	▶BD140	35	BSX20	20	TIP36A	125	2N1132	22	2N3904	10
AF239	75	BC183	10	BD204	110	BSX29	35	TIP36C	135	2N1613	30	2N3905	8
BC107	10	BC183L	10	BD206	110	BSY95A	25	TIP41A	45	2N2218A	45	2N3906	10
BC107B	12	BC184	10	BD222	85	BU205	160	TIP42A	45	2N2219A	25	2N4037	45
▶BC108	10	BC184L	7	BF180	35	BU206	180	TIP120	90	2N2221A	25	2N4058	10
BC108B	12	BC212	10	BF182	35	BU208	170	TIP121	90	2N2222A	20	2N4060	10
BC108C	12	BC212L	10	BF184	25	MJ2955	99	TIP122	90	2N2368	25	2N4061	10
▶BC109	10	BC213	10	BF185	25	MJE340	50	TIP141	98	2N2369	16	2N4062	10
BC109C	12	BC213L	10	BF194	12	MJE520	65	TIP142	98	2N2484	25	2N5457	36
BC114	18	BC214	10	BF195	12	MJE521	95	TIP147	110	2N2646	45	2N5458	36
BC115	22	▶BC214L	8	BF196	12	MJE3055	70	TIP2955	60	2N2904	20	2N5459	30
BC117	18	BC237	8	BF197	12	MPF102	40	TIP3055	55	2N2904A	20	2N5485	36
BC119	35	BC238	14	BF198	10	MPF104	40	TIS43	40	2N2905	22	2N5777	45
BC137	40	BC308	12	BF199	18	MPSA05	22	TIS44	45	2N2905A	22	2N6027	30
BC139	40	BC327	14	BF200	30	MPSA06	25	TIS90	30	2N2906	25	40360	40
BC140	28	BC328	14	▶BF244B	22	MPSA12	30	TIS91	30	2N2906A	25	40361	50
BC141	30	BC337	14	BF245	30	MPSA55	30	VN10KM	50	2N2907	25	40362	50
BC142	25	BC338	14	BF256B	45	MPSA56	30	VN46AF	75	2N2907A	25	40408	70
BC143	25	BC477	30	BF257	32	MPSU05	55	VN66AF	85	2N2926	9		
BC147	8	BC478	30	BF258	25	MPSU06	55	VN88AF	95	▶2N3053	23		
BC148	8	BC479	30	BF259	36	MPSU55	60	ZTX107	10	2N3054	55		

CABLES

20 metre pack single core connecting cable ten different colours.	75p
Speaker cable	10p/m
Standard screened	16p/m
Twin screened	24p/m
2.5A 3 core mains	23p/m
10 way rainbow ribbon	26p/ft
20 way rainbow ribbon	47p/ft
10 way gery ribbon	14P/ft
20 way grey ribbon	28p/ft

HARDWARE

PP3 battery clips	6
Red or black crocodile clips	6
Black pointer control knob	15
Pr Ultrasonic transducers	390
▶6V Electronic buzzer	60
▶12V Electronic buzzer	65
▶PB2720 Piezo transducer	75
▶64mm 64 ohm speaker	70
▶64mm 8 ohm speaker	70
20mm panel fuseholder	25

CAPACITORS

Polyester, radial leads. 250v. C280 type: 0.01, 0.015, 0.022, 0.033 - 6p; 0.047, 0.068, 0.1 - 7p; 0.15, 0.22 - 9p; 0.33, 0.47 - 13p; 0.68 - 20p; 1u - 23p.
Electrolytic, radial or axial leads: 0.47/63V, 1/63V, 2.2/63V, 4.7/63V, 10/25V - 7p; 22/25V, 47/25V - 8p; 100/25V - 9p; 220/25V - 14p; 470/25V - 22p; 1000/25V - 30p; 2200/25V - 50p.
Tag end power supply electrolytics: 2200/40V - 110p; 4700/40V - 160p 2200/63V - 140p; 4700/63V - 230p
Polyester, miniature Siemens PCB: 1n, 2n2, 3n3, 4n7, 6n8, 10n, 15n, 7p; 22n, 33n, 47n, 68n, 8p; 100n, 9p; 150n, 11p; 220n, 13p; 330n, 20p; 470n 26p; 680n, 29p; 1u 33p; 2u2, 50p.

Tantalum bead: 0.1, 0.22, 0.33, 0.47, 1.0 @ 35V - 12p. 2.2, 4.7, 10 @ 25V - 20p; 15/16V - 30p; 22/16V - 27p; 33/16V - 45p; 47/6V - 27p; 47/16V - 70p; 68/6V - 40p; 100/10V - 90p.
Cer. disc. 22p-0.01u 50V, 3p each.
Mullard miniature ceramic plate: 1.8pF to 100pF 6p each.

Polystyrene, 5% tol: 10p-1000p, 6p; 1500-4700, 8p; 6800 0.012u, 10p.
Trimmers. Mullard 808 series: 2-10 pF, 22p; 2-22pF, 30p; 5.5-65pF, 35p

REGULATORS

78L05	30	79L05	45
78L12	30	79L12	45
78L15	30	79L15	45
7805	35	7905	40
7812	35	7912	40
7815	35	7915	40
LM309K	130	LM723	35
LM317K	270	78H05	550
LM317T	90		
LM323K	420		

POTENTIOMETERS

Rotary. Carbon track Log or Lin 1K - 2M2. Single 32p. Stereo 85p. Single switched 80p. Slide 60mm travel single Log or Lin 5K - 500K 63p each.
Preset submin. hor. 100 ohms -1M 7p each.
Cermet precision multiturn, 0.75W ¾" 100 ohms to 100K - 88p each.

TRIACS

		400V 8A	65
		400V 16A	95
400V 4A	50	BR100	25

DIODES

		▶1N4001	3
BY127	12	1N4002	5
OA47	10	1N4006	7
OA90	8	1N4007	7
OA91	7	1N5401	12
OA200	8	1N5404	16
OA202	8	1N5406	17
1N914	4	400mW zen	6
▶1N4148	3	1.3W zeners	13

JUMPER LEADS

Length	14pin	16pin	24pin	40pin
Sgle ended DIP(header plug) jumper				
24 ins.	145	165	240	380
Dble ended DIP(header plug) jumper				
6 ins.	185	205	300	465
12 ins.	195	215	315	490
24 ins.	210	235	345	540
36ins.	230	250	375	595

25 way D Connector jumpers
18ins. long single ended male 495p.
18ins. long single ended f/male 525p.

BRIDGE RECTIFIERS

		2A 200V	40
		2A 400V	45
		6A 100V	80
		6A 400V	95
1A 50V	20	VM18 DIL 0.9A	
1A 400V	35	200V	50

OPTO

▶3mm red	7	▶5mm red	7
▶3mm green	10	▶5mm green	10
▶3mm yellow	10	▶5mm yellow	10

Clips to suit - 3p each.

Rectangular		TIL32	40
▶red	12	TIL78	40
green	17	▶TIL111	60
yellow	17	ORP12	85
▶TIL38	40	TIL100	70
2N5777	45	Dual colour	60

Seven segment displays:

Com cathode		Com anode	
DL704 0.3"	95	DL707 0.3"	95
▶FND500 0.5"	100	FND507 0.5"	100
TIL313 0.3"	115	TIL312 0.3"	115
TIL322 0.5"	115	TIL321 0.5"	115

LCD: 3½ digit 495p. 4 digit 520p.

COMPUTER CONNECTORS

ZX81 2 x 23 way edge connector wire wrap suitable for ZX81 add-ons . . . 150
SPECTRUM 2 x 28 way edge connector wire-wrap suitable for SPECTRUM add-ons . . 200

RIBBON CABLE

Grey Ribbon cable. Price per foot

10 way	14	34 way	58
16 way	25	40 way	68
20 way	28	50 way	90
24 way	38	60 way	100

IDC CONNECTORS

	PCB Plug Straight	Socket	Edge Conn.
10 way	90	85	120
16 way	130	110	175
20 way	145	125	195
26 way	175	150	240
34 way	205	170	320
40 way	220	190	340
50 way	235	200	395
60 way	330	230	495

MIN. D CONNECTORS

	9 way	15 way	25 way	37 way
Plugs solder lugs	60p	85p	125p	170p
Right angle	120p	180p	240p	350p
Sockets lugs	90p	130p	195p	290p
Right angle	160p	210p	290p	440p
Covers	100p	90p	100p	110p

SOLDERING IRONS

Antex CS 17W Soldering iron	495
2.3 and 4.7mm bits to suit	85
CS 17W or XS 25W element	210
Antex XS 25W	525
3.3 and 4.7mm bits to suit	85
Solder pump desoldering tool	480
Spare nozzle for above	70
10 metres 22swg solder	100

RESISTORS

¼W 5% Carbon film E12 series 4.7 ohm - 10M . . . 1p each
½W 5% Carbon film E12 series 4.7 ohm to 4M7 . . . 2p each.
¼W 1% metal film E24 series 10 ohm - 1M . . . 6p each

PCB MATERIALS

Alfac transfer sheets — please state type (e.g. DIL pads etc.)	45
Dalo etch resistant pen	90
Fibre glass board 3.75 x 8"	80
Fibre glass board 8 x 12"	200
Ferric Chloride crystals	100

BOXES

Plastic with lid & screws		Aluminium	
		3 x 2 x 1"	65
		4 x 2¾ x 1½"	95
		4 x 2½ x 2"	95
3 x 2 x 1"	55	6 x 4 x 2"	120
4½ x 3 x 1½"	88	7 x 5 x 2½"	165
7 x 4 x 2"	160	8 x 6 x 3"	205

CONNECTORS

DIN	Plug	Skt	Jack	Plug	Skt
2 pin	9p	9p	2.5mm	10p	10p
3 pin	12p	10p	3.5mm	9p	9p
5 pin	13p	11p	Standard	16p	20p
Phono	10p	12p	Stereo	24p	25p
1mm	12p	13p	4mm	18p	17p

UHF (CB) Connectors:
PL259 Plug 40p. Reducer 14p.
SO239 square chassis skt 38p.
SO239S round chassis skt 40p.
IEC 3 pin 250V/6A.

Plug chassis mounting	38p
Socket free hanging	60p
Socket with 2m lead	120p

SCRs

▶C106D	30
400V 8A	70
400V 12A	95

VOICE SYNTHESISER!

Now your computer can talk. The GI SP0256 speech processor is able through stored program to synthesize speech. Allophone (extended phoneme) system gives unlimited vocabulary.
Easily interfaced with any digital system; ten TTL compatible signals are used to select the allophones.
SP0256 . 850p. Data: 50p.

VERO

VEROBLOC◀	390
Size 0.1 matrix:	
2.5 x 1	22
2.5 x 3.75	75
2.5 x 5	85
3.75 x 5	95
VQ board	160
Veropins per 100:	
Single sided	50
Double sided	60
Spot face cutter	130
Pin insertion tool	162
Wiring pen	330
Spare spool 75p Combs	6

SWITCHES

Submin toggle:
SPST 55p. SPDT 60p. DPDT 65p.
Miniature toggle:
SPDT 80p. SPDT centre off 90p.
DPDT 90p. DPDT centre off 100p.
Standard toggle:
SPST 35p. DPDT48p
Miniature DPDT slide 14p.
Push to make 14p.
Push to break 22p.
Rotary type adjustable stop.
1P12W, 2P6W, 3P4W all 55p each.
DIL switches:
4SPST 80p 6 SPST 80p. 8SPST 100p.

MICRO

		6116P3	320	6852	240	8228	220
		6502CPU	325	6875	495	8251	250
		6522VIA	295	6880	100	8253	390
		6532	570	81LS95	85	8255	225
		6551 ACIA	650	81LS96	85	8259	390
2114L2	99	6800CPU	220	81LS97	85	MC1488	55
2716	240	6802CPU	250	8080A	250	MC1489	55
2532	290	6809CPU	620	8085AC	340	Z80ACPU	290
2732	290	6810RAM	115	8156	350	Z80APIO	260
2764	425	6821 PIA	110	8212	110	Z80ACTC	260
4116P20	85	6840	360	8216	100	Z80ASIO	900
5101L-1	220	6850	110	8224	120	Z80ADMA	1150

SOCKETS

	Low profile	Wire wrap
8 pin	6p	28p
14 pin	8p	45p
16 pin	9p	55p
18 pin	12p	60p
20 pin	13p	68p
22 pin	16p	75p
24 pin	18p	82p
28 pin	23p	95p
40 pin	25p	135p

COMPONENT KITS

An ideal opportunity for the beginner or the experienced constructor to obtain a wide range of components at greatly reduced prices.

¼W 5% Resistor kit. Contains 10 of each value from 4.7 ohms to 1M (total of 650 resistors)	530
Ceramic Cap. kit. 5 of each value - 22p to 0.01u (135 caps)	370
Polyester Cap. kit. 5 of each value from 0.01 to 1uF (65 caps)	575
Preset kit. Contains 5 of each value from 100 ohms to 1M (total 65 presets	425

Nut and Bolt kit (total 300 items): 180p

25 6BA ¼" bolts	50 6BA washers	50 6BA nuts
25 6BA ½" bolts	25 4BA ¼" bolts	50 6BA washers
50 6BA nuts	25 6BA ½" bolts	

CMOS

		4016	20	4034	140	4054	78	4081	12	40193	65	4528	45
		4017	30	4036	249	4055	80	4082	12	4502	60	4529	150
		4018	45	4039	280	4059	430	4085	48	4503	32	4532	60
4000	10	4019	25	4040	40	4060	42	4086	50	4507	35	4534	400
4001	10	4020	42	4041	40	4063	80	4089	125	4508	110		
4002	12	4021	40	4042	38	4066	22	4093	18	4510	45	4543	50
4006	50	4022	45	4043	40	4067	225	4094	68	4511	40	4549	360
4007	14	4023	16	4044	40	4068	13	4095	65	4512	40	4553	215
4008	36	4024	33	4046	40	4069	13	4097	290	4514	115	4555	35
4009	24	4025	12	4047	35	4070	13	4098	70	4515	115	4556	35
4010	24	4026	75	4048	38	4071	13	4099	70	4516	55	4559	390
4011	10	4027	20	4049	21	4072	13	40106	40	4518	40	4560	140
4012	15	4028	40	4050	21	4073	13	40109	110	4520	50	4584	35
4013	20	4029	45	4051	42	4075	13	40163	60	4521	90	4585	60
4014	45	4030	14	4052	48	4076	45	40173	100	4526	60	4724	140
4015	40	4031	125	4053	48	4077	17	40175	75	4527	50		

LS TTL

		LS20	15	LS75	26	LS123	48	LS160	38	LS197	45	LS353	60
		LS21	15	LS76	20	LS125	30	LS161	38	LS221	55	LS365	28
		LS22	15	LS78	20	LS126	30	LS162	38	LS240	60	LS366	28
LS00	14	LS26	15	LS83	35	LS132	35	LS163	38	LS241	55	LS367	28
LS01	14	LS27	15	LS85	42	LS136	28	LS164	40	LS242	58	LS368	29
LS02	14	LS30	15	LS86	24	LS138	60	LS165	50	LS243	58	LS373	58
LS03	15	LS32	15	LS90	25	LS139	30	LS166	70	LS244	100	LS374	60
LS04	15	LS37	16	LS92	25	LS145	60	LS170	80	LS245	78	LS375	43
LS05	15	LS38	16	LS93	25	LS147	95	LS173	60	LS247	50	LS377	60
LS08	15	LS40	16	LS95	40	LS148	90	LS174	36	LS251	36	LS378	57
LS09	15	LS42	30	LS96	95	LS151	40	LS175	36	LS257	32	LS390	45
LS10	15	LS47	38	LS107	40	LS153	40	LS190	40	LS258	35	LS393	40
LS11	15	LS48	38	LS109	30	LS154	95	LS191	40	LS259	60	LS399	56
LS12	15	LS51	15	LS112	27	LS155	30	LS192	40	LS266	24	LS541	78
LS13	18	LS55	15	LS113	28	LS156	36	LS193	40	LS273	55	LS670	35
LS14	33	LS73	20	LS114	28	LS157	26	LS195	36	LS279	32		
LS15	15	LS74	20	LS122	38	LS158	30	LS196	45	LS283	40		

TTL

		7413	25	7444	70	7483	38	74122	38	74161	46	74190	48
		7414	30	7446	55	7485	80	74123	40	74162	40	74191	48
		7416	26	7447	40	7486	26	74125	33	74163	40	74192	48
7400	14	7417	26	7448	42	7489	165	74126	33	74164	45	74193	40
7401	14	7420	16	7450	16	7490	22	74132	36	74165	45	74194	40
7402	14	7421	22	7451	16	7491	35	74141	55	74167	150	74195	40
7403	14	7422	22	7453	16	7492	25	74145	45	74170	125	74196	45
7404	16	7427	20	7454	16	7493	25	74147	75	74173	58	74197	40
7405	16	7428	22	7460	16	7494	35	74148	60	74174	54	74198	80
7406	28	7430	15	7472	24	7495	35	74150	55	74175	50	74199	80
7407	28	7432	22	7473	27	7496	35	74153	36	74176	40		
7408	16	7433	22	7474	23	7497	90	74154	60	74177	42		
7409	16	7437	25	7475	30	74100	80	74155	36	74179	70		
7410	16	7438	25	7476	27	74107	26	74156	36	74180	40		
7411	16	7440	16	7480	48	74109	30	74157	30	74181	105		
7412	16	7442	32	7482	65	74121	28	74160	40	74182	40		

The Rapid Guarantee

★ Same day despatch ★ Competitive prices
★ Top quality components ★ In-depth stocks

ORDERING INFO. All components brand new and full specification. All prices exclude VAT. Please add to total order. Please add 50p carriage to all orders under £15 in value. Send cheque/ P.O. or Access/Visa number with order. Our detailed catalogue is given free with all orders over £15. Callers most welcome. Telephone orders welcome with Access or Visa. Official orders accepted from colleges, schools, etc. . . Callers most welcome, we are open Monday to Friday.

NEXT MONTH

AN ARGUS SPECIALIST PUBLICATION

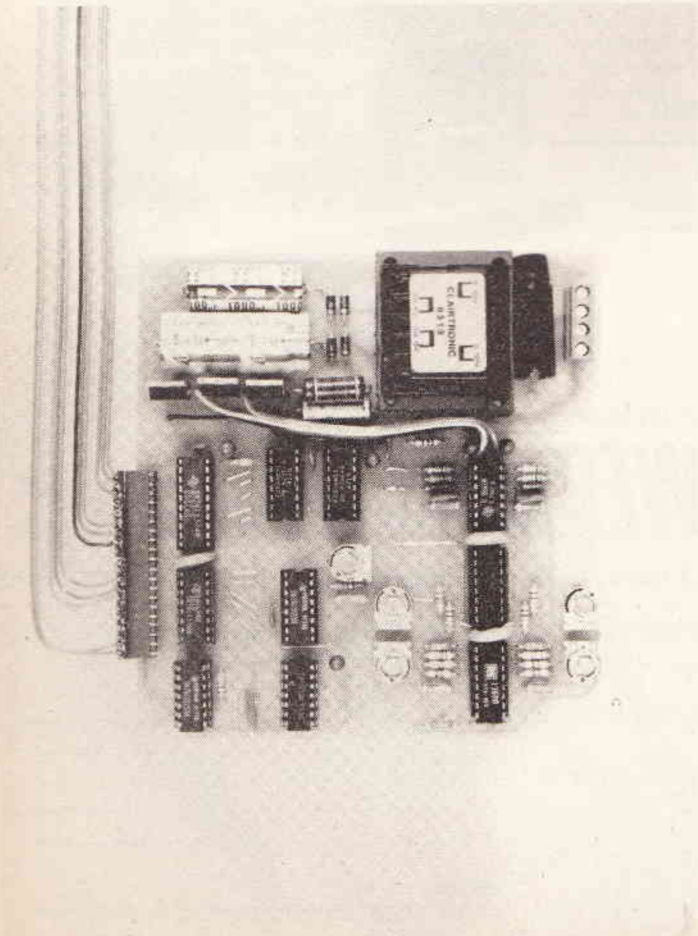
electronics today INTERNATIONAL

AUDIO DESIGN

This month, audio design reaches the seat of the mystique surrounding the whole topic of audio amplifiers — the design of the power section. In true ETI fashion, we intend to boldly separate fact from fiction, truth from fantasy, and infinitives from their verbs!

VECTORGRAPHICS

There is an alternative to using a raster-scanned display — that of using vectors drawn across the screen directly. Phil Walker has produced a system for experimenters to play with, using a ZX81.

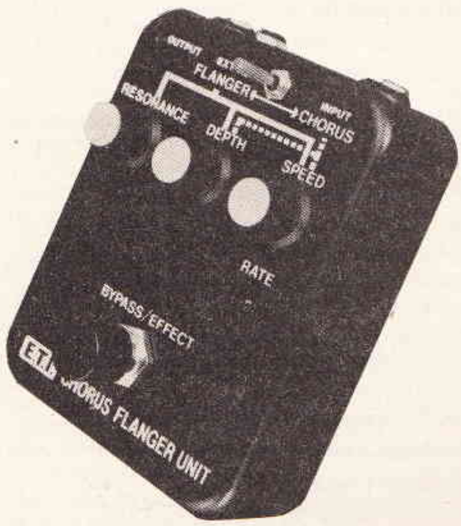


EPROM PROGRAMMING

We were so overwhelmed with requests for photocopies of the assembler listing for the EPROM programmer published in our August issue that we asked Mike Bedford to produce some notes on how to interconvert the program for other home computers. We'll be published this, along with the listing for the benefit of the very few of our readers who have not already requested it from us!

CHORUS/FLANGER

This project is designed by Tim Orr — who has absented himself from our pages for a while, but has recently learned better. It's for a chorus/flanger unit that can be used with guitar, bass guitar, high-output microphone, keyboards, or, in fact, almost anything that you can attach to a jack-plug.



LOOK OUT FOR THE JANUARY ISSUE ON SALE DECEMBER 2nd

Articles described here are in an advanced state of preparation. However, circumstances may dictate changes to the final contents.

BUILD YOUR OWN cortex

16 bit, 64K RAM colour computer

With this powerful machine (featured in Electronics Today International as a constructional project) you have access to highly advanced systems and software developed specially by MPE Ltd for the CORTEX. For business, education, R & D – or simply increasing your knowledge and understanding of computers – it beats comparably priced off-the-shelf machines hands down!

STATEMENTS IF ELSE ON GOTO GOSUB POP REM FOR NEXT ERROR INPUT PRINT ; ? ' 1 UNIT BAUD CALL DATA READ RESTOR RETURN STOP TIME WAIT SAVE LOAD MOTOR ESCAPE NOESC RANDOM ENTER LIST PURGE NUMBER RENUM BOOT GRAPH TEXT PLOT UNPLOT COLOUR CHAR SPRITE SHAPE SPUT SGET MAG TOF TON DIM LET DEF NEW END BIT CRB CRF MEM MWD BASE

COMMANDS RUN SIZE CONT MON

DELIMITERS TO TAB STEP THEN @ # ? % $! & ( ) [ ]

FUNCTIONS FNA-FNZ ABS ADR ASC ATN SIN COS EXP FRA INT LOG SQR SYS TIC SGN BIT CRB CRF MEM MWD LEN MCH POS COL MOD RND KEY

OPERATORS OR LOR AND LAND NOT LNOT LXOR = > >= < <= <> - + / * ^

Standard features –

- High speed 24K byte extended basic interpreter
- Powerful TMS9995 16 bit microprocessor
- 48 bit floating point gives 11 digit accuracy
- High resolution (256 x 192) colour graphics
- Screen memory does not use up user memory space
- 16 colours available on the screen together in graphic mode
- Fast line drawing and point plotting basic commands
- High speed colour shape manipulation from basic
- Full textual error messages
- String and Array size limited only by memory size
- Real time clock included in basic
- Interval timing with 10mS resolution via TIC function
- Named load and save of basic or machine code programs
- Auto-run available for any program
- Powerful machine code monitor
- Assembler and Disassembler included as standard
- Auto line numbering facility
- Full renumber command
- Simple but powerful line editor
- Buffered i/o allows you to continue executing the program while still printing
- Flexible CALL statement allows linkage to machine code routines with up to 12 parameters
- Basic programs may contain spaces between key words to make programs readable without using more memory
- Over 34K bytes available for basic programs
- Extended basic includes IF-THEN-ELSE
- Supports up to 16 output devices: Screen and cassette interfaces included as standard
- Supports bit manipulation of variables from basic
- Error trapping to a basic routine included
- Basic supports Hexadecimal numbers
- Separate 16K video RAM for graphics

Self assembly kit

£295

Ready built £395

All prices + VAT
Carriage paid

Optional extras

RS232C interface kit	£9.20
Floppy disc interface	£65.50
Pair of 5½" disc drives and hardware kit	£365.00

Ready built

CORTEX B – Basic machine + RS232C	£410.00
CORTEX C – as above + disc drives	£895.00

Full assembly instructions and 216 page user's manual.

POWERTRAN cybernetics

Portway Industrial Estate, Andover SP10 3NM. Tel: 0264 64455

To POWERTRAN CYBERNETICS, Portway Industrial Estate, Andover, Hants SP10 3NM.

Please send me ______________________

I enclose cheque for ______ or charge to:

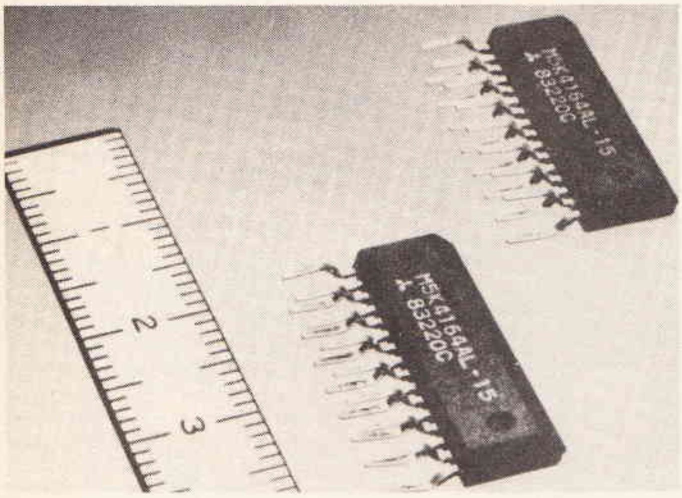
Access/ Barclaycard A/C No. [ ]

Name ______________________

Address ______________________

______________ Tel. ______________

DIGEST



ZIL-Package 64K DRAMs

Mitsubishi Electric Corporation has put on the market the first 64-kilobit dynamic random access memory (DRAM) in a 16-pin, zigzag in-line (ZIL) package for high-density installation.

The plastic-mold ZIL-package 64K DRAM is available in 120ns and 150ns versions, and is designed to achieve high-density installation at prices similar to those of existing plastic mold dual in-line package chips. The ZIL package measures 20.2 mm in length, 2.8 mm in width and 8.3 mm in height. Space required for installation is $56.6mm^2$, about 47% of the space required for the company's existing dual in-line package chip.

Mitsubishi Electric plans to sell the new 64K DRAMs to makers of high-resolution graphic displays, mainframe computers and other products requiring high-density installation of chips. Mitsubishi Electric Corporation, 18th Floor, Centre Point, 103 New Oxford Street, London W2, tel 01-379 7160.

Home Made Bread?

If you're coming to Breadboard this year (what do you mean, if? — ED.) better make sure you have a hand free. You might be the lucky person who carries off A.B. Engineering's superb tool kit.

Worth over £100, the kit is supplied in a real leather wallet and is intended to supplement rather than duplicate your existing tool kit. Thus basic tools like a soldering iron, which it is assumed most constructurs will already possess, are not included but less frequently encountered tools like a desoldering gun and cut and bend tool are. With this lot plus your regular tool kit you should be in a position to make and repair just about anything.

Visitors to the show will be invited to place their name and address on a consecutively numbered pad. On Sunday afternoon a winner will be selected using an electronic random number indicator (vicious rumours which claim that we are actually planning to use the circulation figures of rival publications are simply not true — we can't have people squabbling over the lowest numbered sheets!).

Exhibitors at Breadboard will be showing such diverse items as electronic organs, test equipment, books, kits, PCBs, components and much, much more. There will be demonstrations of robots and the opportunity to try out the latest in video games consoles, the CBS Colecovision. This is the game that has taken America by storm and received rave reviews after its appearance at America's largest computer show.

If all the flitting from exciting exhibit to even more exciting exhibit wears you out, you could do worse than to pay a visit to the lecture room. There you will not only have the chance to rest your weary feet but to expand your knowledge at the same time. The complete lecture programme is given below.

Finally, a reminder that the cost of admission to Breadboard will be £2.50 (but watch out for the 50p off vouchers in our ads) and the times are as follows:—
Friday 25th November 10.00-6.00
Saturday 26th November 10.00-6.00
Sunday 27th November 10.00-4.00

Lecture Programme

Friday 25th November	
11.00 Electronics in Civil Aircraft Today	— F. Ellson-Jones
12.00 Electronic Music	— R. Watts
13.00 Soldering — A Neglected Art?	— R. I. Cato
14.00 Holography — Practically There	— A. Pepper
15.00 Add-ons for Microcomputers	— O. Bishop
16.00 Designing and Making Printed Circuits	— K. E. Tippey
Saturday 26th November	
11.00 Soldering — A Neglected Art?	— R. I. Cato
12.00 Electronics in Civil Aircraft Today	— F. Ellson-Jones
13.00 Holography — Practically There	— A. Pepper
14.00 Add-ons for Microcomputers	— O. Bishop
15.00 Electronic Music	— R. Watts
16.00 Successful Project Design	— A. Armstrong
Sunday 27th November	
11.00 Gateway to Electronics	— D. Bradshaw
12.00 Add-ons for Microcomputers	— O. Bishop
13.00 Designing and Making Printed Circuits	— K. E. Tippey
14.00 Electronic Music	— R. Watts
15.00 Successful Project Design	— A. Armstrong

Autoranging DMM

The new VR-3500 series of hand-held autoranging digital multimeters from Hitachi include temperature measurement among their wide range of functions. Models VR-3510 and VR-3525 have built-in scaling and cold junction compensation for standard K type thermocouples. Surface mounting and protector tube probes working over the range −20 C to +700 C are available from Hitachi, but any K type thermocouple can be used including low-cost bead types.

The VR-3500 series features manual or automatic range selection on voltage and resistance with manual ranging on current from 0.1uA up to 10 amps. Other facilites include a selectable continuity bleeper, a diode test range, and a data hold function. Three models are available with accuracies varying between 0.1% and 0.5%, and all share a common styling with a case which fits easily into the hand.

The Hitachi VR-3500 series is available ex-stock from Reltech Instruments and prices start at £82 plus VAT. Reltech Instruments, New Road, St Ives, Cambs, tel 0480 63570.

Molecular Electronics

Marconi Avionics Limited is to establish a Chair in Molecular Electronics, at the School of Industrial Science, Cranfield Insitute of Technology, and to support the research for five years.

Molecular Electronics, a term which was originally used to describe the development of organic materials with useful electrical properties, is now taken to cover a far wider field of materials and processes. One such organic material is polyvinylidene flouride (PVDF) which, combining the mechanical properties of a plastic and the piezo-electric properties of a crystal, can be used to great advantage in microphones and other pressure-sensitive devices. Many new potential applications for it are already beginning to appear.

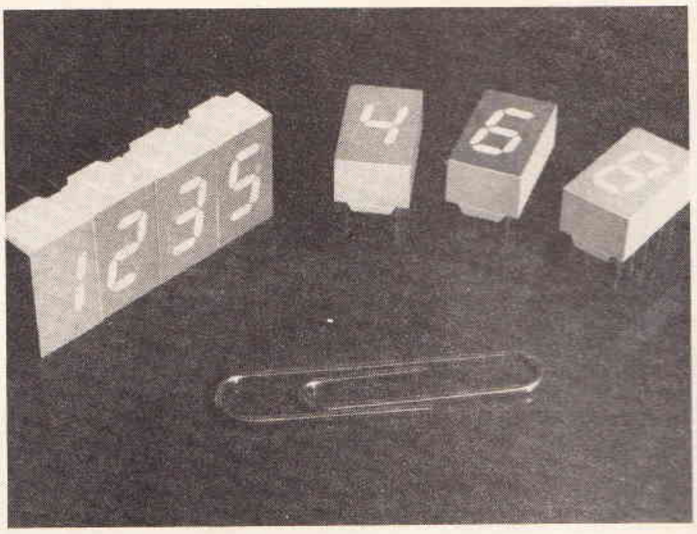
Another important use of molecular material is in electrochromic displays, in which the movement of ions in an electrolyte changes the colour absorption at its surface. These can be developed for a great range of exciting new applications. One such might be as colour liquid crystal displays to replace the monochrome displays which are now in common use in digital watches.

Other fields of known interest at present include new and environmentally-stable materials for use instead of gelatin in new kinds of holographic optics, and germanium, the semi conductor material first used for making transistors and now an important part of modern thermal imaging systems.

250 Watt 30 MHz Transistor

Motorola has introduced the MRF448, a 250 Watt NPN transistor believed to offer the highest power currently available at this frequency. The device is intended for operation in the 30 MHz band with a 50 volt supply and features 14 dB (typ) of gain, 65% efficiency and intermodulation distortion of −33 dB (typ). It is designed primarily for high-voltage applications in high-power linear amplifiers and is said to be ideal for marine and base station equipment.

For further information readers should contact Motorola Ltd., European Literature Centre, 88 Tanners Drive, Blakelands, Milton Keynes MK14 5BP, tel 01-352 041 extn 34.



Single-Chip CRT Controller

NCR Corporation has introduced a single-chip CRT display controller that can be mask programmed to provide a wide variety of special features and display modes.

Designated the NCR 7250 CRT Controller, it is designed to provide a well-defined interface block between standard microprocessors and microcomputers, and any CRT display. Mixed character and graphic modes, including mosaic and line graphics, are standard features. Nine internal registers are externally addressed to control all display features, including page scrolling, complete cursor-position control, and eight different screen attributes. These include blank screens, reverse video, video chop and enable cursor, while field attributes include reverse video, blink, blank, video highlight graphics and underline.

The NCR 7250 can be used to display up to 80 x 25 characters with a character cell size of up to 9 x 12. All video signals and up to 240 characters are internally generated, and interleaved CPU access-cycles and auto incrementing address registers give it the ability to update or read a dedicated Video RAM at direct memory access (DMA) rates.

Designed to directly interface with a CRT monitor via the VSYNC and HSYNC outputs, an input clock signal and single RAM are all that is required to produce the video display output. NCR Limited, 206 Marylebone Road, London NW1 6LY, tel 01-388 8244.

Long Wavelength Photo Diode

Hitachi Ltd have developed a new photo diode made of a compound of indium, gallium, arsenide and phosphorus. Employing a PIN structure, the HR1101 is sensitive to light in the wavelength range between 1.0 and 1.5 microns and has a maximum quantum effieciency of about 70%, an indication of its high sensitivity.

Reflecting recent needs for long-distance and large-volume data transmission, the technical trend has been toward the use of the 1.0 and 1.5 micron range where the transmission loss of an optical fibre is at a minimum. In this long wavelength range, the germanium avalanche photo diode has up to now been the only practical choice, but it is not sensitive or fast enough for applications which require higher performance and reliability because its dark current and noise rate are apt to be high and it requires a high supply voltage. The compound employed by Hitachi and the use of a planar structure with a window layer has made it possible to attain high quantum efficiency by protecting the electron-hole pairs generated by photons from disappearing in recombination, and to reduce the electrostatic capacitance, thus improving speed. The HR1101 has a dark current of 7 nA compared with 100-1000 nA for a germanium avalanche photo diode and operates on 5-10 V supplies compared with the germanium device's 30-40 V.

Hitachi says that these technologies help to increase not only the performance and reliability of the HR1101 but also its production yield. Hitachi Electronic Components (UK) Ltd, tel 01-861 1414.

Mini Seven-Segment Display

A new 0.3 inch (7.6 mm) seven-segment LED display available in standard red, high-efficiency red, yellow and green has been announced by Hewlett-Packard Company. Features such as bright, evenly lit segments, a low forward-drive current, a small, space-saving package and an attractive character front characterise these new HDSP Series displays.

Compared with HP's existing family of 0.3 inch LED displays, this new family requires up to 25% less current and can still be viewed at distances of up to 10 feet (3 metres). Increases of up to 50% in viewed brightness are possible when the displays are driven at typical drive currents of 5 and 10 mA, making them well suited for high ambient-light applications. The display package is 0.3 by 0.5 inches (7.62 by 12.7 mm) and is pin-for-pin compatible with Fairchild's FDN 35X/36X. Details from the Literature Section, Hewlett-Packard Limited, Eskdale Road, Winnersh, Wokingham, Berkshire RG11 5DZ, tel 0734 69662.

High Performance 16 bit ADC

Data Beta have announced a new high-speed analogue-to-digital converter, the ZAD7402, which has a resolution of 16-bits with a relative accuracy of ± 0.0015% FSR and a typical conversion time of six microseconds (seven maximum).

Monotonicity is guaranteed and there are no missing codes over the operating temperature range of 0 to 70 C. The converter accepts inputs between +10V and −10V or 0 and 10V and exhibits a differential linearity of ±0.5 LSB with a temperature coefficent of only 0.8ppm/ C. Offset drift is a low 1.5ppm/ C and Output codes are binary, offset binary, and twos complement.

Contained in a compact 76 x 117 x 10 mm metal case which gives RFI shielding on six sides, the ZAD7402 runs from ±15V [illegible] power supplies and consumes approximately 3.5W. Price for 25 off is £670 each and delivery is 4-6 weeks. Data Beta Limited, 23A Buckingham Avenue, Slough, Berkshire SL1 4QA, tel (0753) 7933/4.

Reels on Wheels

The latest thing for the 'discerning on-location recordist', so Marantz tell us, is this smart looking portable stereo cassette recorder. Designated the CP430, it and its little brother the CP230 replace the Superscope CD320 and CD330 machines which Marantz have been selling over here for some time.

The two new models are both smaller and lighter than their forbears, offer considerably increased battery life, and have been designed so that no knobs, switches or connectors protrude from the case, affording the maximum protection should they be accidentally dropped. They feature normal, chrome, and metal tape compatibility, fine bias control, speed variable by ± 5%, memory rewind, illuminated VU meters, and the ability to monitor either channel independently through the built-in loudspeaker. Powering can be by dry batteries, an optional rechargeable battery pack, or from the mains using the adaptor supplied via the 4.5v input jack. Connecting the mains adaptor also charges the battery pack. Line input and output sockets are included so that they can be used with a domestic sound system, mixer etc.

The CP230 is a two head machine with both Dolby B and C noise reduction and costs £169.90 including VAT.

The CP430 has three heads, allowing off-tape monitoring, and has both Dolby B and dbx noise reduction. It costs £249.90 including VAT.

Optional extras include the EM 8 microphone and the RBD430 rechargeable battery pack, both at just under £30 inclusive. Both models come complete with the mains adaptor and a carrying case which incorporates a pocket for the microphone. Marantz Audio UK Ltd, 15-16 Saxon Way Industrial Estate, Moor Lane, Harmondsworth, Middlesex UB7 0LW, tel 01-897 6633.

Hall Effect Devices

Following our feature on Hall effect devices in the October issue, a number of companies and individuals have contacted us to ask where the ICs mentioned in the article can be obtained. The short answer is, almost nowhere. There seems to have been so little interest in Hall effect devices in the past that few suppliers have bothered stocking them at all, and those that do rarely offer more than one type. Let us hope that the interest generated by this article will improve matters (advertisers please note!).

So where can you get Hall ICs? Farnell Electronic Components Limited of Canal Road, Leeds LS12 2TU, can supply the UGN3501M but they will only deal with industrial and professional customers. Watford Electronics, who advertise in our pages, can supply a device called the UGN3020T which is similar to the UGN3019T mentioned in the article and comes in the same package. Maplin stock three Hall ICs, two of them switches and one a linear device. None of them were mentioned in the article but you should find enough information in the Maplin catalogue to enable you to use them successfully.

If anyone out there knows of any other suppliers of Hall devices, especially ones who will deal directly with the public and who stock any of the devices mentioned in the article, please let us know and we will give them a mention in a future Digest.

Videotone Switch

Regular readers will remember that we reviewed the Videotone Minimax 2 speakers back in our September issue. At a press reception recently, they told us that they have already changed the speakers.

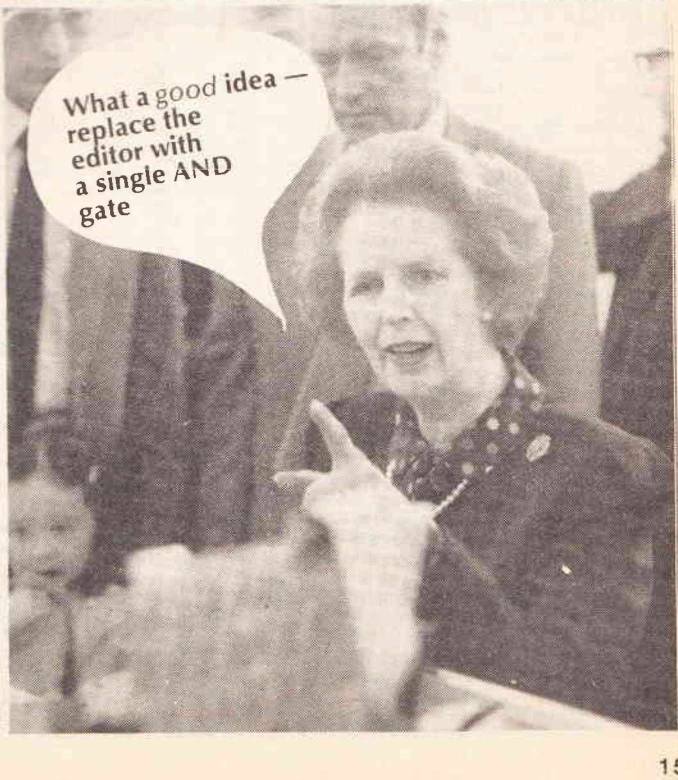
The new speakers are still called Minimax 2, although they're now produced in Hungary (the first 2s were made in the UK). The drive units are different, the material of the port is different, the connectors are different — in fact, the whole lot is made by the Videoton company in Hungary, which is a separate entity from Videotone Ltd of the UK.

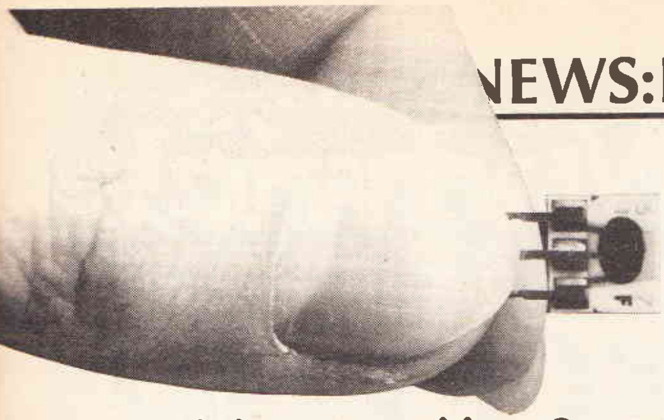
Videoton claim that the two speakers are very similar indeed, and that any differences are to the favour of the newer version. They certainly sounded OK when driven by the super-fi set-up at the reception — although we didn't get a chance to compare them with the MK1 2s.

Also being launched were two new bookshelf-size speakers, imported from Hungary. The DB1312 is an even smaller two-way system, priced at £49.90 and a three-way system at £99.90 per pair.

To add to this, Videotone will be selling a new budget moving coil high-output cartridge; it's called the MC 88E and sells for £27.90. Also new, is a top-line MC cartridge with a Van den Hul stylus for £114.90, the MC87.

Videotone Ltd, 1st Floor, 55 North Street, Thame, Oxfordshire OX9 3BH; tel 0844-21 6929.





Miniature Position Sensor

Honeywell has introduced a low cost version of its smallest, ceramic-packaged, Hall effect sensor. Consisting of an epoxy-coated IC mounted on a 7.6 mm ceramic square, the 8SS has a temperature range from 0 to 50°C making it ideal for room temperature applications.

The 8SS has a two-state digital output and responds to variations in magnetic field, generated by approach and withdrawal of an external magnet. Small size and an operating frequency of 100 kHz make it extremely versatile. Applications include sensing of cam position, ignition timing, potentiomenters, tachometers and wherever a miniature sensor is needed. A linear output version is also available.

8SS devices are available for two voltage ranges: 4.5 to 5.5 V DC and 6 to 16 V DC, and output is either bipolar or unipolar current sink. Maximum operate magnetic field is +0.0025T Tesla, minimum release is −0.025T, and minimum differential is 0.004. Mounting and package options available include lead wires, solder pads only or variations on the standard PCB termination pins. The corners of the ceramic can be cropped to reduce the size of the package where space is at a premium.

Marconi Spins a New Yarn

Marconi Space & Defence Systems Limited has developed a novel solution to the problems traditionally encountered in producing electrical cable harnesses. Such work has previously been carried out on a peg board and has been time-consuming and labour intensive.

The solution and the product, 'Marconiweave', is based on a unique adaptation of standard weaving machinery, and can meet the requirements for quality and reliability imposed by military standards. 'Marconiweave' allows a user to specify hybrid woven cables combining different types of construction — flat, multilayer and tubular — and to combine a wide range of different wire gauges and insulation factors. Many kinds of multicore cable may be specified including screened varieties, and any length can be woven into a flat cableform. The fact that 'Marconiweave', can also be woven in the form of a tube allows extra wires to pass through the centre and to accommodate other services such as small tubes carrying liquids or gases. Tubes and optical fibres can also be combined with wires in a flat ribbon and spacers can be inserted automatically to maintain a constant and controllable distance between wires.

Applicatons for 'Marconiweave' are foreseen in many areas of communications, especially those where the position of each wire relative to every other wire must be held constant. Further applications exist in the fields of computers, test equipment and many other installations involving large numbers of electrical connections. Marconi Space & Defence Systems Limited, West Avenue, Kidsgrove, Staffordshire, tel 07816 3501.

SHORTS

● A note of gloom to start the winter on. Business information company Dun & Bradstreet Ltd inform us that 562 electrical companies went into liquidation during the first nine months of this year, an increase of 11.5% over the same period last year. There were 72 bankruptcies in the industry in the same period and this represents a 9% increase on last year's figure.

● Have you been ripped-off? Inmac's new sprocket-hole reinforcer tape will repair damaged computer printout as well as protecting undamaged printout. Made of tough clear vinyl, it is simply cut to length and the pre-punched holes aligned with those of the printout. Further information can be found in the free, full colour catalogue which is available from Inmac (UK) Ltd, Davy Road, Astmoor, Runcorn, Cheshire WA7 1QF, tel 09285 67551.

● Lloyd's Register of Shipping have produced a unique English/Japanese dictionary of technical terms. Although aimed primarily at the shipbuilding industry, it covers a wide range with 5000 entries in 192 pages, and best of all, it's free. Lloyd's Register of Shipping, 71 Fenchurch Street, London EC3M 4BS, tel 01-709 9166.

● K.E. Developments have produced a range of printed circuit mounting DC-DC converters which offer a choice of regulated and un-regulated fully isolated outputs from standard 5 and 12 volt inputs. the converters are available in 2.5 and 6 watt versions with efficiencies of 50% and 70% respectively and with outputs of ±5v, ±12V, ±35V, +180V, and +240V. K.E. Developments Ltd, The Mount, Toft, Cambridge CB3 7RL, tel 022 026 3532.

● Another useful address for everyone out there with a mutilated multimeter. Aughton Automation Ltd of 29 Woodward Road, Kirby Industrial Estate, Liverpool L33 7UZ, can repair and re-calibrate most electrical and electro-mechanical test equipment. Their telephone number is 051 548 6060.

● Bring your Sinclair up to date with Glanmire Electronics' new Time Controller. Consisting of a battery backed up real time clock, it provides the computer with month, day, date, hours, minutes, and seconds and has eight programmable inputs and eight programmable outputs and an extension for the attachment of further peripherals. Available for the ZX81 at £34.50 and for the Spectrum at £38.50 direct from Glanmire Electronics Ltd, Westley House, Trinity Avenue, Bush Hill Park, Enfield EN1 1PH, tel 01-366 3245.

● Toolrange's Combi-Check is a hand-held combined voltage and continuity tester. It detects the presence of 6, 12, 24, 50, 110, 220, 380, and 660 V DC or up to 100 Hz AC, displaying the result on a row of LEDs, and will make polarity and continuity tests at up to about 2M ohms. Operating from a 12V battery and with an input resistance of 660k, the Combi-Check is available from Toolrange Ltd, Upton Road, Reading, Berkshire RG3 4JA, tel 0734 29446.

● The Institution of Electrical Engineers are to hold a one-day colloquium on 'Techniques of Medical Imaging'. It will take place on Wednesday 23rd November at the IEE headquarters at Savoy Place and will cost non-members £33.35 plus lunch. The IEE, Savoy Place, London WC2R 0BL, tel 01-240 1871.

● Thorn EMI Electron Tubes Ltd have published a paper called "Voltage Divider Design" which deals with design of divider networks for use with photomultiplier tubes. The paper covers such requirements as linearity, scintillation counting, speed of response, etc, and is available free from Thorn EMI Electron Tubes Ltd, Bury Street, Ruislip, Middlesex HA4 7TA, tel 08956 30771.

● The PBL 3747 monolithic IC is designed to solve matching problems wherever a high impedance source must be fed into a low impedance load. Incorporated in a TO-92 plastic package, the device has an output impedance of 60 ohms, an input impedance of 66M ohms, 1% distortion at its maximum output of 200 mV, and 2.5 dB gain at 1000 HZ. Contact RIFA AB, Market Chambers, Shelton Square, Coventry, tel 0203 27259.

● National Panasonic have introduced three new sizes of 3V Lithium - Polycarbonmonofluoride batteries to their range for use in memory support and long-life standby applications. New sizes are 2/3 AAA with 300 mAh capacity (10.5 mm dia x 30 mm) and A size with 1.9 Ah capacity (17 mm dia. x 41.4 mm). Cells are available with either solder tags or pins and have a shelf life in excess of 10 years. Special Batteries Division, Panasonic Industrial (UK) Ltd, 300-318 Bath Road, Slough, Berkshire SL1 6JB, tel 0753 34522.

● The Open Computing School offers courses in everything from beginners BASIC to the more sophisticated information retrieval systems. Courses are self-paced and students can choose their hours of attendance. A 15 hour BASIC course costs £45. Details from Jack Flatau, Polytechnic of the South Bank, Borough Road, London SE1 0AA, tel 01-928 8989 extension 2468.

● Cumana have introduced a new 5¼" disc drive for the BBC and Dragon microcomputers which will be sold through High Street outlets such as W.H. Smiths. The drives have their own power supply, are available in 40 and 80 track single sided and 80 track double sided versions, and come with a 12 month guarantee. Two drive can be used simultaneously with the BBC and up to four with the Dragon.

16 CHANNEL A/D CONVERTER

Get your micro to do some real work with the aid of our versatile unit. Design by Bob Campbell.

Connecting one's micro to the outside world is probably one of the most rewarding and exciting computing projects that you can undertake. Not only that but it is often extremely useful — a carefully designed central heating control system could save you enough money to pay for the project itself!

To link the digital world of the micro to the real world of analogue signals an interface is required. The interface is used either to turn a digital signal into some meaningful voltage or current, or to convert a voltage into a digital signal so that the computer can interpret it. The digital to analogue converter side of things was more than adequately covered in the March issue of ETI, so this article will present the other side of the coin, the analogue to digital converter. As with the previous project, this design is based on the Tangerine Micron Microtan 65 system, but consideration has been given to the question of adapting the design to suit other systems, including Z80 based computers.

The circuit is designed around the industry standard ADC0808 or ADC0809, both of which are 8 bit, 8 channel, microprocessor compatible analogue to digital converters. The difference between the 0809 and 0808 is the accuracy, being ± 1 LSB and ± ½ LSB respectively. The converter is a CMOS device made by National Semiconductor amongst others, and uses a conversion technique known as successive approximation. This technique usually provides fast conversion times, together with good overall accuracy. Other features of this converter are single supply operation, no zero or full scale adjustments required, low power, and guaranteed monotonicity. This last point can be very important, particularly in high speed closed loop feedback systems. Non-monotonicity in such situations would produce oscillation, which could be catastrophic for the system being controlled.

The main conversion elements of the 0808 are a high impedance, chopper stabilised comparator, a 256R voltage divider network and an analogue switch tree, together with the all important successive approximation register. In front of the converter is an 8 channel analogue multiplexer controlled by a 3 bit address latch, giving the converter access to any one of eight single-ended analogue signals. Figure 1 shows the internal block diagram of the converter.

The circuit is designed on the International-size card to suit the Microtan, and includes provision for two converters giving a maximum of 16 channels. The remainder of the circuitry consists of the data bus buffers and address decoding, and IC3 which is used to convert ∅2 and the R/W line into NRS and NWS (NOT READ STROBE and NOT WRITE STROBE). Processors like the Z80 already have these as $\overline{RD}$ and $\overline{WR}$, and thus do not require IC3 to be fitted.

The decoding section is very similar to that used in all other recent Microtan designs. IO is the only non-standard signal, and this is decoded with A3-A9 inclusive to produce 128 eight byte addresses, any 8 of the 128 being available at any one time. The remaining three address lines A0 to A2 are used to

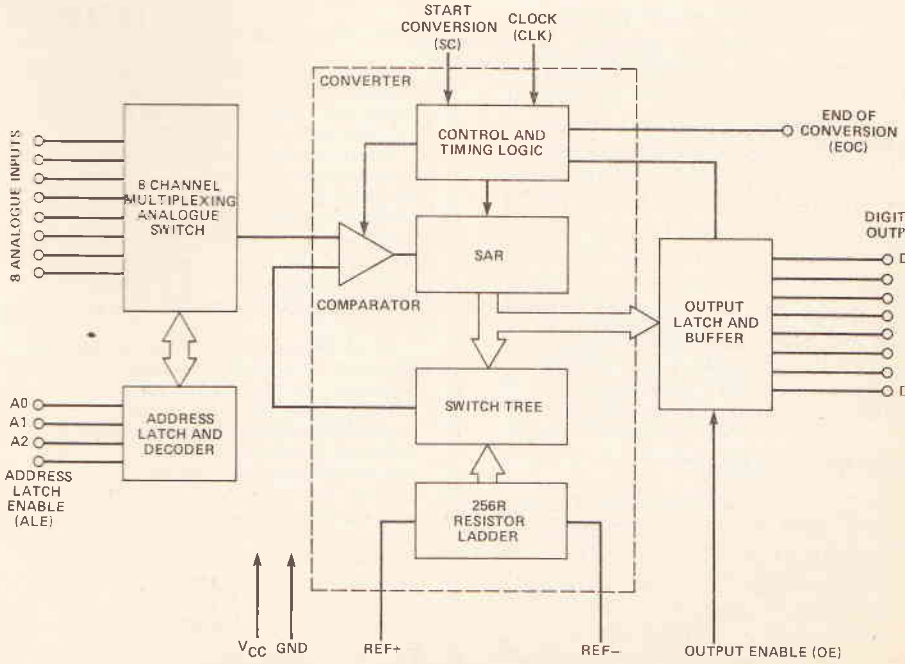
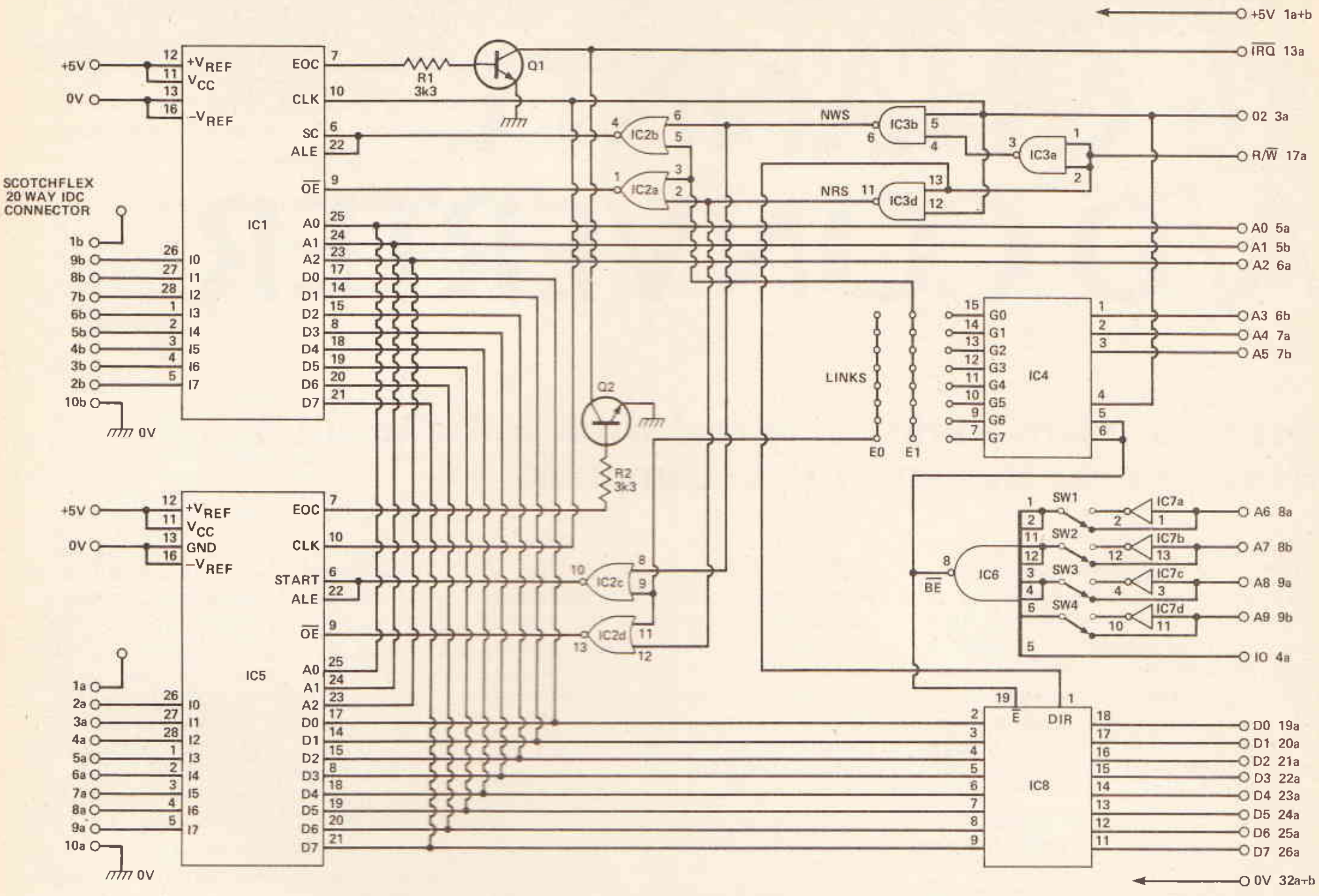


Fig. 1 Internal block diagram of the ADC0808.



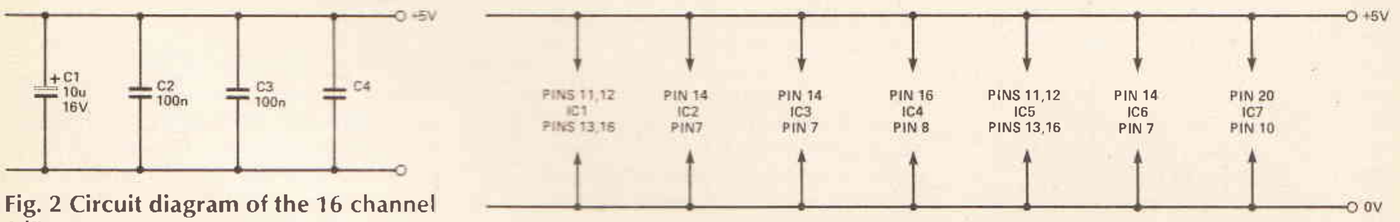


Fig. 2 Circuit diagram of the 16 channel A/D converter.

select the input channel for the converter. Setting the address of each converter is accomplished with DIL switches SW1-4 and with links between G0-G7 and E0, E1. SW1-4 set up the overall addresses of the 8, eight byte blocks and the links are used to select the individual block of each converter within the overall address. For example, setting SW1-4 to 1, E0, to G., and E1 to G1 will give us an address block 16 bytes long, BC00 to BC07 for IC1 and BC08-BC0F for IC5 (48128 to 48135 and 48136 to 48143 inclusive.)

Construction

Before commencing construction you should decide which of the various circuit options you wish to include. IC3 may not be needed depending upon the micro-processor you are working with, and R1, R2, Q1, and Q2 will

HOW IT WORKS

Since the operation of the circuit is quite well covered in the section on programming and elsewhere, we will devote this section to the ADC0808/9 itself.

There are three main elements to the converter, the successive approximation register (SAR), the comparator and the resistor ladder-switch tree array. In addition there is a 1 of 8 analogue multiplexer to select the input signal, timing and control logic, and tristate data buffers, which as a whole form the data acquisition circuit.

The SAR is reset on the positive edge of the start conversion pulse, and if another SC signal is applied during an incompleted conversion the current conversion will be aborted in favour of the new request. Continuous conversion cycles can be obtained by tying the end of conversion (EOC) output to the SC input.

The analogue signal, 1 of 8 selected by the multiplexer, is fed through to the comparator. this comparator is responsible for the accuracy and repeatability of the converter and the 0808/9 uses a chopper stabilized technique to achieve the specified stability and accuracy. The other output to the comparator is from the switch tree and is equivalent to the previous approximation to the input signal. The comparator first converts the DC input signal to an AC signal then boosts this through a high gain AC amplifier before restoring the DC level. Thus any DC drift component of the input signal is filtered out at this stage, prior to the actual conversion taking place.

The output of the comparator is then fed to the SAR which in turn controls the next output from the switch tree. Thus on each successive iteration the output of the switch tree is fed back via the comparator to the SAR to form the next iteration. On the eighth iteration the output will be within ½ LSB of the ideal value.

Data is then available at the outputs, after taking OE low. Overall timing of the conversion is controlled directly by the clock input, which should be between a minimum of 10KHz and 1.28MHz maximum.

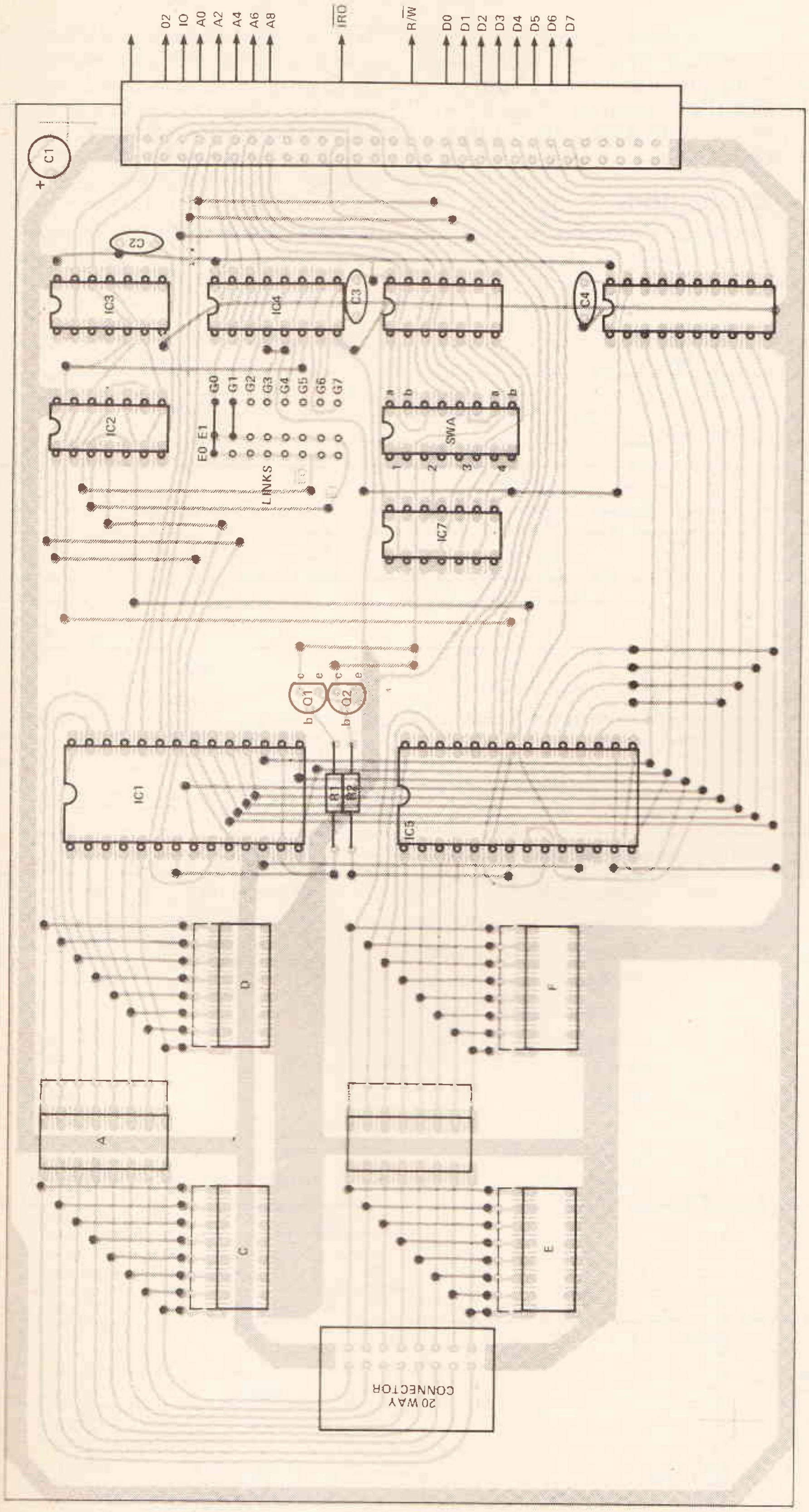


Fig. 3 Component overlay of the PCB. The blocks marked A, B, C, D, E, and F are positions where input filter components may be inserted. If none are used, links should be inserted in positions A and B.

not be needed if you plan to use interrupt driven routines. Provision has been made for the inclusion of various input filter and attenuator components on the board, and if none is used you will have to insert links in their place. The standard arrangement is a simple 1k series resistor but a number of possibilities exist and a few examples are given in Fig. 4. Since every application is different it is not possible to cover every requirement, and you may find it necessary to experiment a little here.

As with previous projects, a double sided board has been used but without plated through holes. This helps to keep the cost down, but it does mean that a lot more care has to be taken in the construction. The positions of the through board links are shown on the component overlay drawing, Fig. 3. Sockets have been specified for all the ICs and should certainly be used for the A/D converters at least because these are CMOS. The DIL switch could, of course, be replaced with wire links, and whilst the switches are preferable they are certainly not cheap.

With the assembly complete, the next stage is the programming. To initiate a conversion of a specific analogue channel a write operation on that address must be performed. This could be, for

PARTS LIST

Resistors

R1, 2	3k3 ¼W 10% (see text)

Capacitors

C1	10u 16V radial
C2, 3, 4	100n ceramic

Semiconductors

IC1, 5	ADC0808 or ADC-0809 (see text)
IC2	74LS02
IC3	74LS00 (see text)
IC4	74LS138
IC6	74LS30
IC7	74LS04
IC8	74LS245
Q1, 2	BC184, BC109 etc (see text)

Miscellaneous

DIN 41612 64 way indirect edge connector; 20 way male PCB header and matching IDC socket; PCB; 4 x 14 pin DIL sockets, 1 16 pin, 1 20 pin, and 2 x 28 pin sockets; DIL switch, quad SPDT; ribbon cable, input filter components, etc.

BUYLINES

Technomatic can supply the ADC0808 and the DIN indirect edge connector, and the 20 way IDC connectors are available from Ambit. Nothing else should cause any problems, and the PCB is available through our PCB service, see page 74.

example, POKE 48128,0 in BASIC or STA BC00 in assembler. This latches the address and pulses the SC input via IC2 starting the conversion on that channel. Assuming for the moment that the system clock used is 750 kHz and that the EOC link has been omitted, then we must wait for 80 μs before the converted data is available on the data bus. It is a simple matter then to read from the same address as before to obtain that data. For example DATA = PEEK (48128) or LDA BC00. The OR gate IC2 makes sure the decoded signal E0 or E1 and the NRS ($\overline{RD}$) are both low before pulsing the $\overline{OE}$ input of the converter and enabling the tristate buffers. In fact on the authors system the time delay associated with BASIC means that PEEKing immediately after POKEing the required channel address works well, eg

```
10 POKE AD, 0
20 DATA = PEEK (AD)
30 PRINT DA
40 GO TO 10
```

By connecting the EOC link the need for the time delay routine can be avoided. In this case the EOC signal is used to pull the $\overline{IRQ}$ line low on the processor causing an interupt, which must be handled in the normal manner with an interupt service routine. Such a routine is difficult to implement in BASIC but is very simple in machine code or assembler. One particular point to note if using this technique is the EOC delay time, which is the delay before EOC is reset after a new SC signal is sent. It is important therefore that interupts are not enabled before this time has elapsed. Figure 5 shows the timing diagram for the converter.

Applications

The most common use of an A/D converter is simply to measure a voltage generated or controlled by the equipment under observation. The voltage transducer may be anything from a strain gauge amplifier to something as simple as a variable resistor acting as a potential divider. This latter case is an example of a ratiometric type

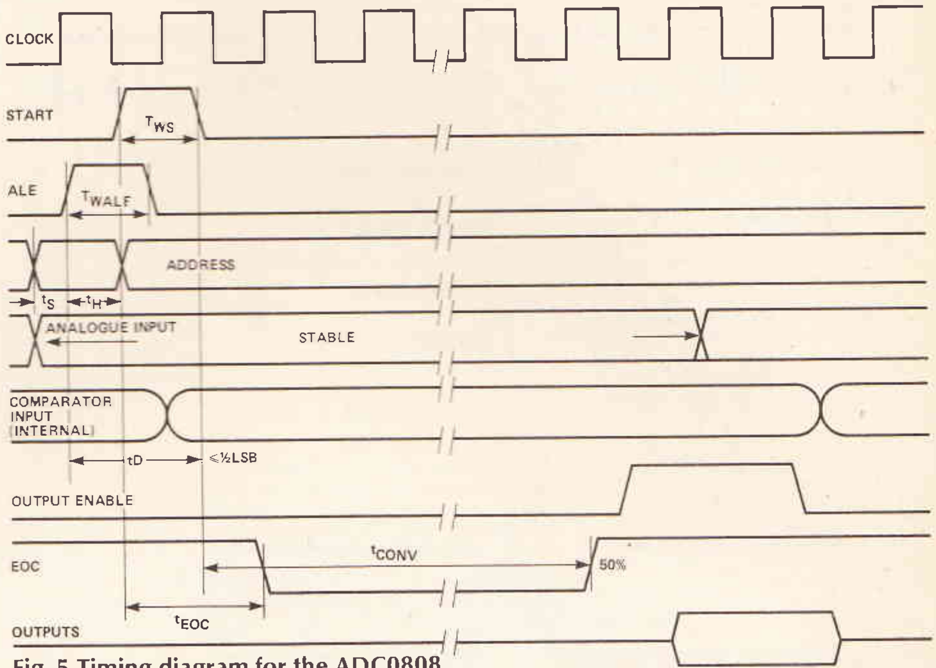


Fig. 5 Timing diagram for the ADC0808.

SYMBOL	PARAMETER	MIN	TYP	MAX
T_{WS}	Minimum Start Pulse Width		100ns	200ns
T_{WALE}	Minimum ALE Pulse Width		100ns	200ns
t_S	Min Address Set-Up time		25ns	50ns
t_H	Min Address Hold Time		25ns 50ns	
t_D	Analog MUX Delay Time from ALE		1us	2.5us
t_{EOC}	EOC Delay Time	0		8 clock cyc + 2.0 us
t_{CONV}	Conversion time	90us	100us	116us
f_c	Clock Frequency	10kHz	640kHz	1280kHz

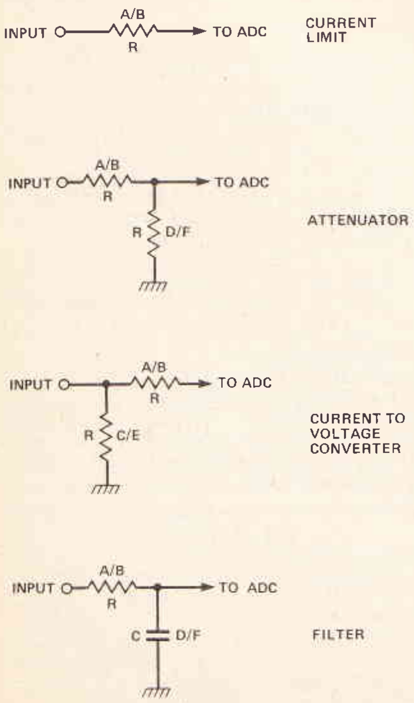


Fig. 4 Input circuit arrangements.

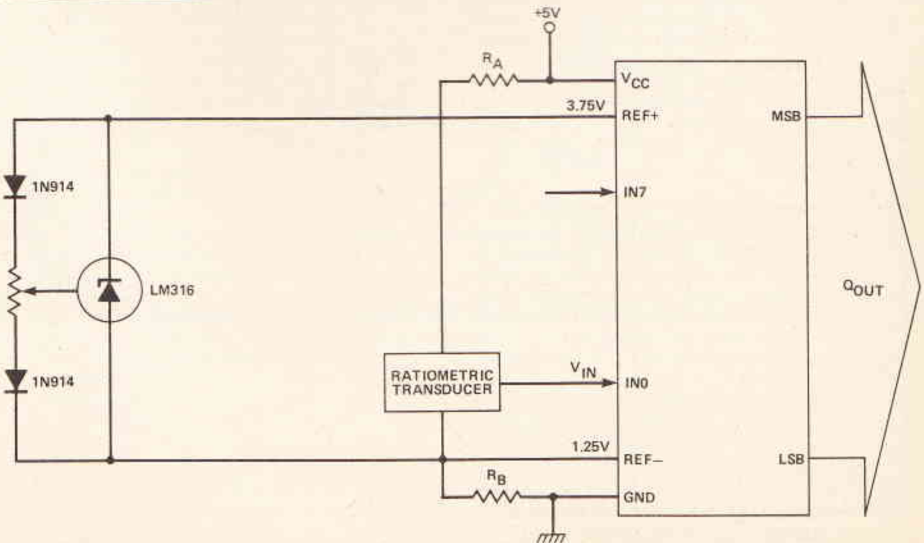


Fig. 6 Ratiometric conversion

of transducer, where the input being measured is expressed as a percentage of full scale which is not necessarily related to any absolute standard. This type of transducer has several advantages, particularly in low cost systems since the need for a highly stable and accurate reference voltage is reduced, often to the point where the supply voltage itself is more than adequate.

The ratiometric conversion technique equation is

$$\frac{Vin}{Vfs - Vz} = \frac{Dx}{Dmax - Dmin}$$

where
Vin=input voltage into the ADC0808
Vfs =full scale voltage
Vz =zero voltage
Dx =data point being measured
Dmax = maximum data limit
Dmin =minimum data limit

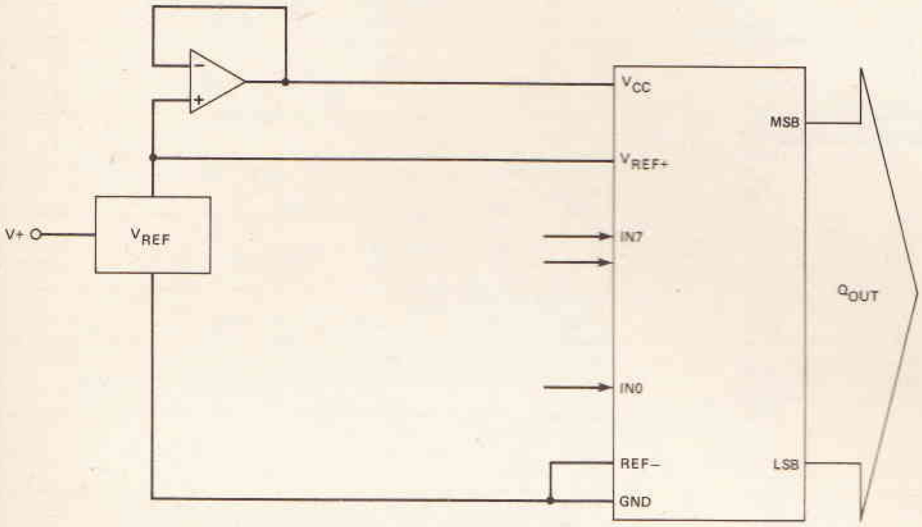
Applying this equation to the potentiometer example shown in Fig. 6 we get

$$Qout = \frac{Vin}{Vref} = \frac{Vin}{Vcc}$$

where 4.75V Vcc = Vref 5.25V and the Qout is the 8 bit digital output.

The most obvious example of a use for the potentiometer as a transducer is a position encoder, which could be a joystick or a rotary shaft encoder on a robot axis motor. In fact the uses for such a transducer are almost endless and similar ratiometric transducers include thermistor bridges, pressure transducers, etc.

Some applications require the measure to be made with reference to an absolute standard voltage or current. There are two widely used methods of reference conversion, ground referenced and centre referenced. In each case there are numerous ways of producing the supply and reference voltages, and examples are shown in Figs. 7 and 8.



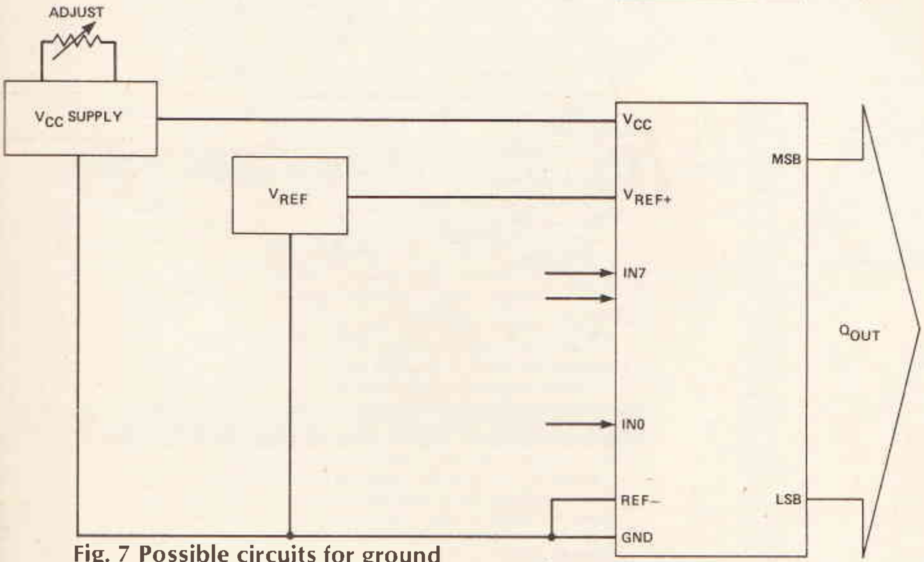


Fig. 7 Possible circuits for ground referenced systems.

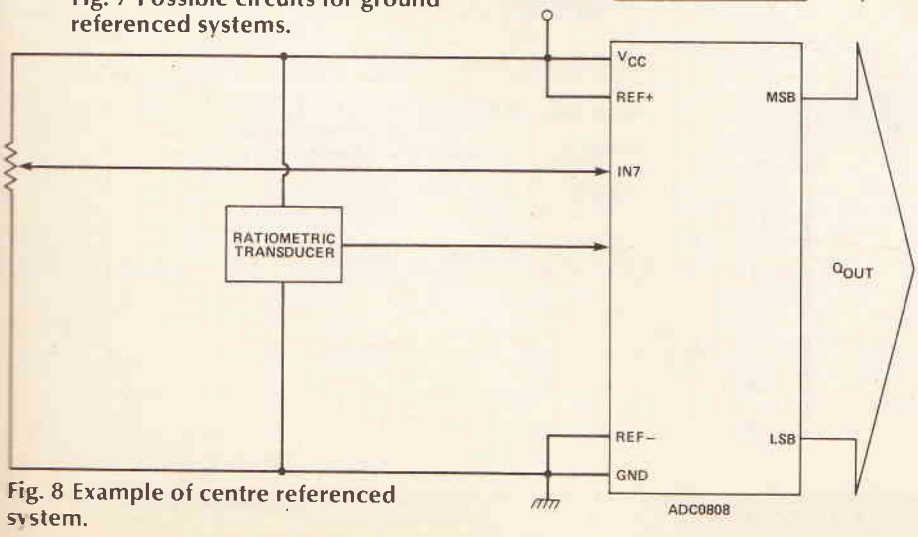


Fig. 8 Example of centre referenced system.

Z80 Conversion Notes

As mentioned in the introduction, the modifications necessary for the Z80 procesor are very straight-forward. IC3 can be omitted and the $\overline{RD}$ and $\overline{WR}$ lines directly substituted for NRS and NWS. There are no write operations involving data valid for this board, and FIR on IC9 (pin 1) should be connected to an inverted RD or taken permanently high.

A0 to A7 inclusive are identical but in the Z80 case must be used with the $\overline{IOREQ}$ line to decode an output address. The simplest way to achieve this is to substitute A0 — A7 directly, $\overline{IOREQ}$ for A8, and tie A9 and 10 permanently high. This obviously means SW4 must always be in position 2, and SW3 in position 1. The master clock, pin 10 on IC1 and IC5 should be taken to any TTL clock of a suitable frequency i.e. between 10 KHz and 1.2 MHz. A 4 MHz system clock divided by four with the aid of a 74LS74 would prove suitable.

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ETI

MACHINE CODE PROGRAMMING

Is relative addressing an example of keeping it in the family? This, and other questions, will be answered in the third part of our series on Machine Code Programming, written by Bob Bennett.

Last month I gave a couple of CPU addressing mode examples, but before I give any more I would like to explain a couple of things. First, whenever possible, I will give other CPU direct equivalents to the Z80 instructions, but I can't possibly mention every CPU. What I hope to do is make it possible for you to recognise your own particular CPU instructions. To help you do this, don't pay too much attention to the *name* of the addressing mode, but rather what *happens* because of the instruction; different manufacturers have, at times, used slightly different terminology to describe similar actions. The second point is that every example I will give the hex code first followed by the mnemonic thus, 00h — **NOP.**

Although machine code doesn't use line numbers, the BASIC statement GO TO 100 has a very near equivalent in machine code, but the comparison cannot be taken too literally. These equivalents are the **jump** or **branch** instructions, part of which form the relative addressing mode. In this mode the instructions are two bytes long, the first byte is the function, and the second is the offset. The Z80 instruction set the straightforward jump instruction code is 18h — **JR,e,** or jump relative by the amoung of the offset byte e. Why relative? Well, the value of the offset byte indicates a destination for the jump, relative to the current program position.

Because the offset is only one byte, the maximum jump is 255d (d = decimal) or FFh locations, but in which direction? The numbers 0 to 255d are positive, so a forward direction is indicated; this leaves the problem of going backwards. No sweat, the answer lies in the use of the 2's complement. Never heard of it? Don't worry, all will become clear.

Take the maximum range of a byte, 0 to 255d, and split it; the first section, 0 to 127d (7Fh) are the forward or positive range. The second step is where it might get confusing so watch it carefully: the numbers that are left from 128 to 255d or 80 to FFh, but, because we need a backwards, or negative, direction, the decimal numbers now range from −128 to −1.

Remember that I said you would need a knowledge of the binary system? This is where it comes in handy. The binary equivalents of the decimal numbers 0 to 127 and 128 to 255 are 0000 0000 to 0111 1111 and 1000 0000 to 1111 1111 respectively. A closer examination shows that, throughout the first set of numbers, but 7, the leftmost bit, is 0; and throughout the second set, bit 7 is 1.

This makes it possible for bit 7 to be used as a sign bit: reset, or 0, for positive; and set, or 1, for negative. To get the value of the offset byte is easy. Counting the byte *after* the offset byte in the program as zero, count backwards or forwards until you reach the destination for the jump, as shown in Fig. 6. Another method would be to take the destination address, and the zero address, take the lower from the higher, and add the sign accordingly.

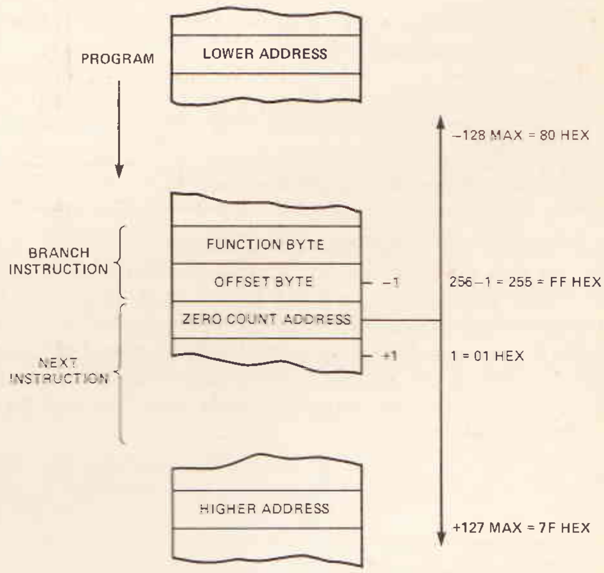


Fig. 6 **Counting the value of the offset byte.**

Assume that you have counted 100 places backwards; Fig. 7 shows what happens next. Alternatively, if you subtract the backwards count from 256d, the answere is a decimal number equal to the 2s complement, which you then convert to hex.

```
Binary
0110 0100 = 100 decimal (ignore sign)
1001 1011 = l s complement i.e. change is l s to 0 and vice versa
        1   add 1
1001 1100 = 156 d or 9C hex, which is the offset byte value
|
└──────────► Bit 7 is set which means a negative count
```

Fig. 7 2's complementing a backwards (negative) count.

Some CPUs do not have a straightforward relative jump/branch in the instruction set, but some do support the conditional relative jumps/branches. This is similar to the BASIC IF X = 0 THEN GO TO 100. The Z80 instruction 28h — **JR Z,e** means jump relative if the zero flag is set, by the amoung of the offset e. The 6502 code is F0h — **BEQ** which means branch when zero flag set. Usually most of the flags can be used in the set or reset condition for relative jump or branch instructions.

Absolutely So

Although the relative jumps and branches are sometimes of great help in a program, their range is rather limited as I have shown. To get further afield requires slightly different techniques, and different instructions of course. This set of instructions require an absolute destination, or address, to be specified in the instruction. For those of you who like analogies, relative addressing is like saying 'go to the third house past the church' and the absolute equivalent is 'go to 31 Church Street'. This type of jump or branch is only a part of the absolute addressing mode instructions, but for now I'll deal with jumps.

Because, in theory, the whole of our 64K memory is reachable, the addresses will have to be in two bytes, so the total bytes for absolute addressing is at least three. There are special cases that require just one byte, and some that need four, but I'll cover them later. Let's assume for now that we need to jump unconditionally to address 30,000d; Fig. 8 showns how to prepare the decimal number into the two byte hex number we need.

FIRST STEP: divide decimal address by 16
16 ⟌30,000 = 1,875 remainder 0 = 0 x units
SECOND STEP: divide this by 16
16 ⟌1,875 = 117 remainder 3 = 3 x 16
THIRD STEP: divide again by 16
16 ⟌117 = 7 remainder 5 = 5 x 16
As the result is less than 16, we stop therefore 30,000 decimal = 7530 hexadecimal

Fig. 8 One way of converting decimal to hex.

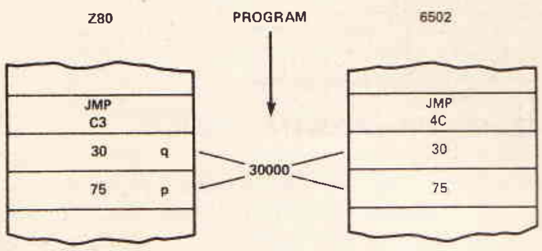


Fig. 9 Absolute jump instructions.

The Z80 instruction C3 — **JP pq**, where pq are the address bytes, and the 6502 instruction, 4C — **J,MP** are both examples of jump in the absolute mode. Fig. 9 shows how both examples would be used in a program, when the destination was address 30,000d. Note that the low byte of the address goes straight after the code for jump; please accept that this is so for now, and I'll explain more later on.

In some of the instruction sets the flags status, or condition, can be used just as in the relative jumps.

Leaving the jump/branch instructions let's have a look at some more absolute instructions. The Z80 instruction 3A — **LD A,(pq)** means load the A register with the contents of the address pq. Note the use of brackets in the mnemonic; without them the instruction would mean: load the A register with the two byte number pq; two into one won't go! To get the number in the A register into the address pq, the instruction in the Z80 set is 32 — **LD (pq),A.**

This mode of addressing need not be restricted to a single register; a Z80 example is 2A — **LD HL,(pa)**, where the byte in pq is loaded into L and the byte in pa+1 is put into H. If you forget which byte goes where, just remember H for high (byte), and L for low; using the DE pair, the high byte will go into register D.

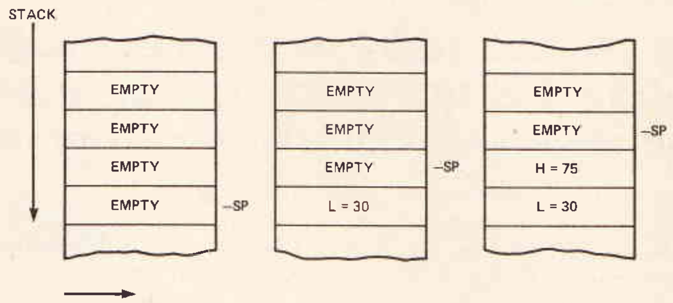


Fig. 10 Pushing the number 7530hex in the HL pair.

Those of you with Sinclair micros may have noticed, in the manual appendix dealing with the character set, the words 'after ED' or 'after CB' etc. This is where a four byte absolute instruction may be found, and is explained as follows. The instruction 4B in the Z80 set means **LdC,E,** but after ED means **LD BC,(pq).** Fig. 10 shows how this is used in a program. The use of ED and CB, etc., is very similar in principle to the use of shift keys, where one key with shift has a different function to the unshifted version.

A Direct Extension

This section should explain, in part at least, some of the differences in terminology that I mentioned earlier. In one book I read a few weeks ago, the author gave an example of absolute addressing, using 3A — **LD A,(pq)** for the Z80 set. He went on to say that this mode is sometimes called the direct or extended mode. As the 6800 set uses both of these modes I'll give a couple of examples.

In the direct mode, the instruction 96h is concerned with loading the accumulator with the byte held in an address, but there is only one byte used for the address. This is because the high byte of the address is supplied by the computer automatically, and the byte is 00. So, when the computer meets the instruction 96,FF, it interprets it as meaning **Ld A,(pq)**, where pq is 00FF. An example of the extended form from the 6800 set is 87 — **LD (pq),A** where the two bytes pq must be put in by the programmer. As a last example, I'll use the 8085 set; in that set 3A — **Ld A,(pq)** is considered as being in the direct mode.

Now for a little bit more explanation of terminology. That 6800 direct mode example I gave above is sometimes called **zero page addressing,** or sometimes, **abbreviated absolute form.** No matter what it is called, it still works in the manner that I have described. Those of you with a 6502 can use zero page addressing, which simply means the first page (of RAM) runs from addresses 0000 to 00FF. All you have to do as a programmer is specify the low byte of the address from 00 to FF, and the computer adds the 00 automatically, as already explained. Now you can see that it does help to known how your computer has its memory mapped out. A computer that has ROM starting at address 0000 cannot use zero page addressing in the form **Ld (pq),A**, because you cannot write to ROM.

Pop Goes The Weasel

In the instructions that I've already covered, the two bytes, pq, have been used as an address. Later on I will be giving addressing mode using pq as numbers, but for now more explanations. These explanations concern not only what has gone before, but what is yet to come. Firstly, let us recall the stack pointer register, SP, as we'll be looking at this in rather more detail.

As you will recall, the stack is a portion of RAM which the computer reserves for its own use, and, like the variables area, the size can fluctuate. The stack is used to store two byte addresses or numbers, either at the command of the programmer, or as part of a computer controlled sequence. Curiously, the stack is sort of upside down, with the latest piece of information going on top of the one before, which makes for a last in, first out, situation.

To help you understand the stack, and the manipulation of pq, I am going to use two single-byte instructions. These are the **PUSH** and **POP**, or **PUSH** and **PULL** instructions. Because pq takes up two bytes push and pop concern register pairs. The Z80 set allows the push and pop of every register pair (see part one of this series) and also allows the A register to be paired with the flags register, F, for this purpose. Don't be misled, though: the use of the AF pair allows only A to be loaded (with any number up to FFh), but you can't load the F register.

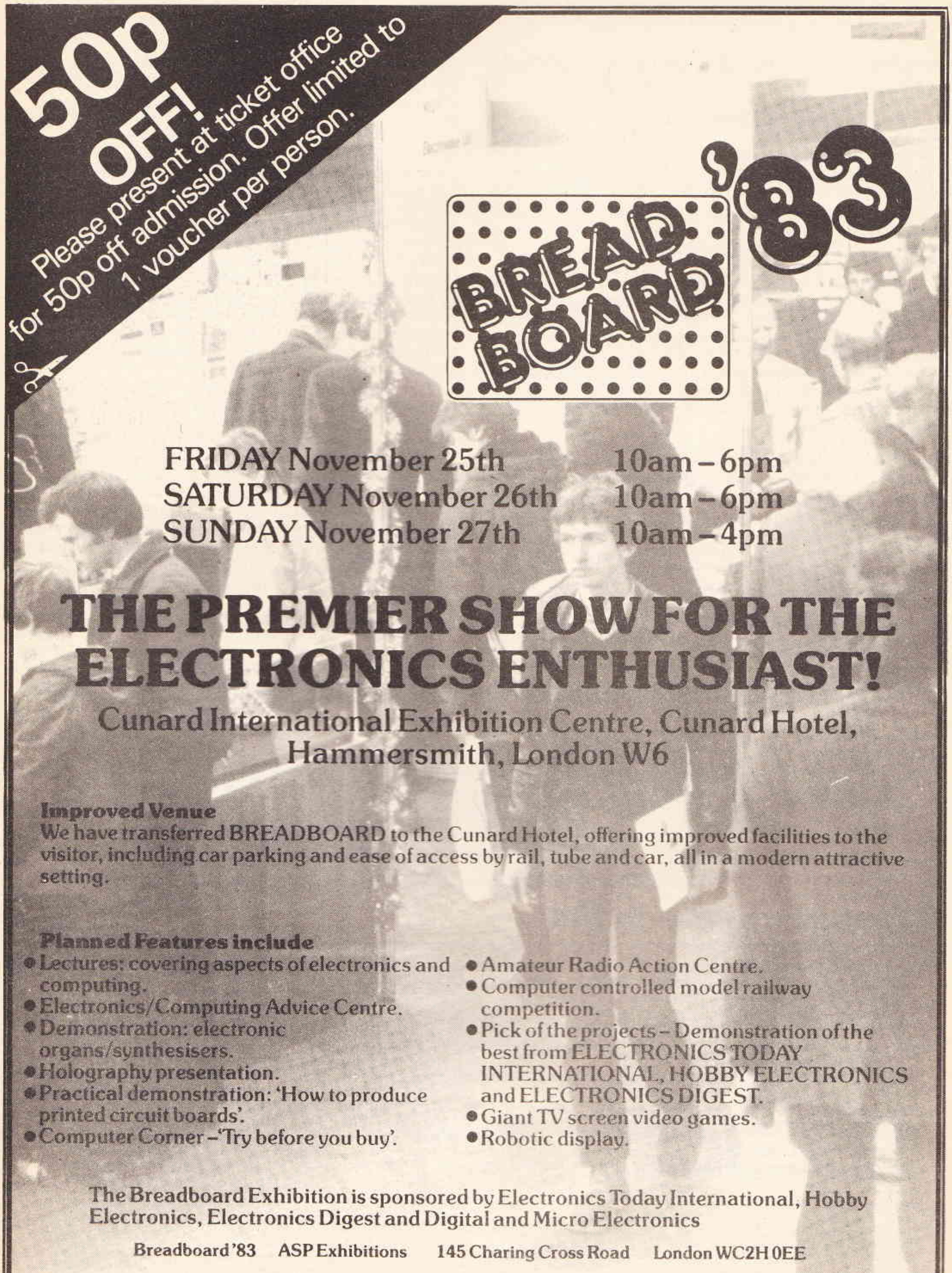
Using the HL pair to make things clearer, the Z80 instruciton EF — **PUSH HL** will store the contents of HL on the stack. See Fig. 10 while following the explanation. Supposing HL contained the number or address 30,000d or 7530h before the instruction E5 — **PUSH HL** was encountered by the program. On reaching E5 the stack pointer will be pointing to the next empty address available on the stack. First the low byte in L is copied into that address. The stack pointer, sp, is then decremented (by one) and the high byte in H is copied into the new address pointed to by SP. The register is decremented again so that it is now pointing to the next available address.

The reverse happens on the pop instruction which, in the Z80 set is E1 — **POP HL**. This instruction will increment SP (by 1), the byte in the new address is copied into H; SP is incremented again, and the next byte goes into L. Now SP is pointing to the next available address on the stack.

The 6502 set allows the pushing and popping of only two single registers onto the stack. These are the accumultor and the status register; for example, 48 — **PHA** copies the contents of the accumulator onto the stack. Notice that I keep saying copies onto the stack: this is to emphasise the fact that pushing does not destroy the contents of registers.

The final couple of points will be of interest to Z80 users mainly. If you have pushed a sequence of register pairs onto the stack, before popping them off again remember the last in, first out rule. Having said that, what happens if you push HL then pop DE? With that question, we'll leave you pondering until ETI pops through your letter box next month . . .

ETI



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ZX BURGLAR ALARM

Why let intruders POKE around at your ADDRESS when you could get them on the RUN with this natty little unit? Designed by Declan Ciaran McMahon.

This microprocessor controlled security system will monitor up to eight remote switch positions each of which can be either normally open or normally closed, allowing you to use any combination of pressure mats, magnetic catches, window foil or other devices as the sensors. When triggered, it immediately sounds an alarm and then displays the number of the affected input on a seven-segment LED. It can be used with either the ZX81 or the Spectrum and quite aside from its value as an intruder alarm it provides a useful introduction to the techniques of microprocessor interfacing using machine code and the Z80 Parallel Input/Output Controller.

The Z80 PIO consists of two groups of eight lines, port A and port B, and each line can act as eigher a data input or output. If the IN instruction is used, the data on those lines defined as inputs is loaded into the accumulator. If the OUT instruction is used, data on the accumulator is latched onto the output lines. The PIO can be programmed to act in any one of four modes:

Mode 0 — Output mode
Mode 1 — Input mode
Mode 2 — Bidirectional mode
Mode 3 — Control mode

The first three modes require the use of the handshaking facilites and so for this design the much simpler control mode has been used, allowing easy input and output of data to and from both eight bit ports on the PIO. Port A provides the eight inputs from the sensing switches while port B is split into four inputs and four outputs, the inputs being used to enter data while the outputs feed the seven segment display. An eight bit word is entered via port B into the register which tells the microcomputer which of the input lines should be high and which low (corresponding to normally open and normally closed

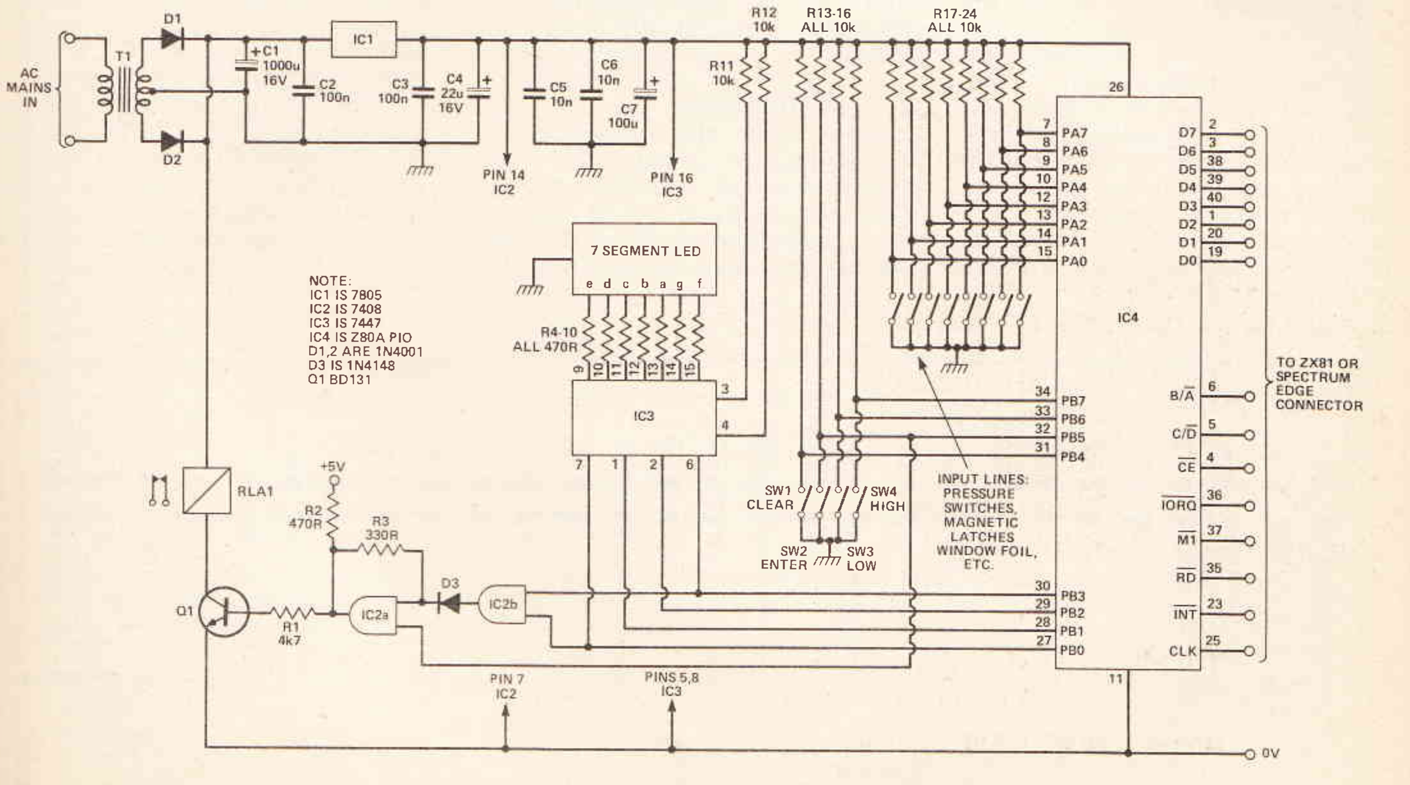


Fig. 1 Circuit diagram of the burglar alarm.

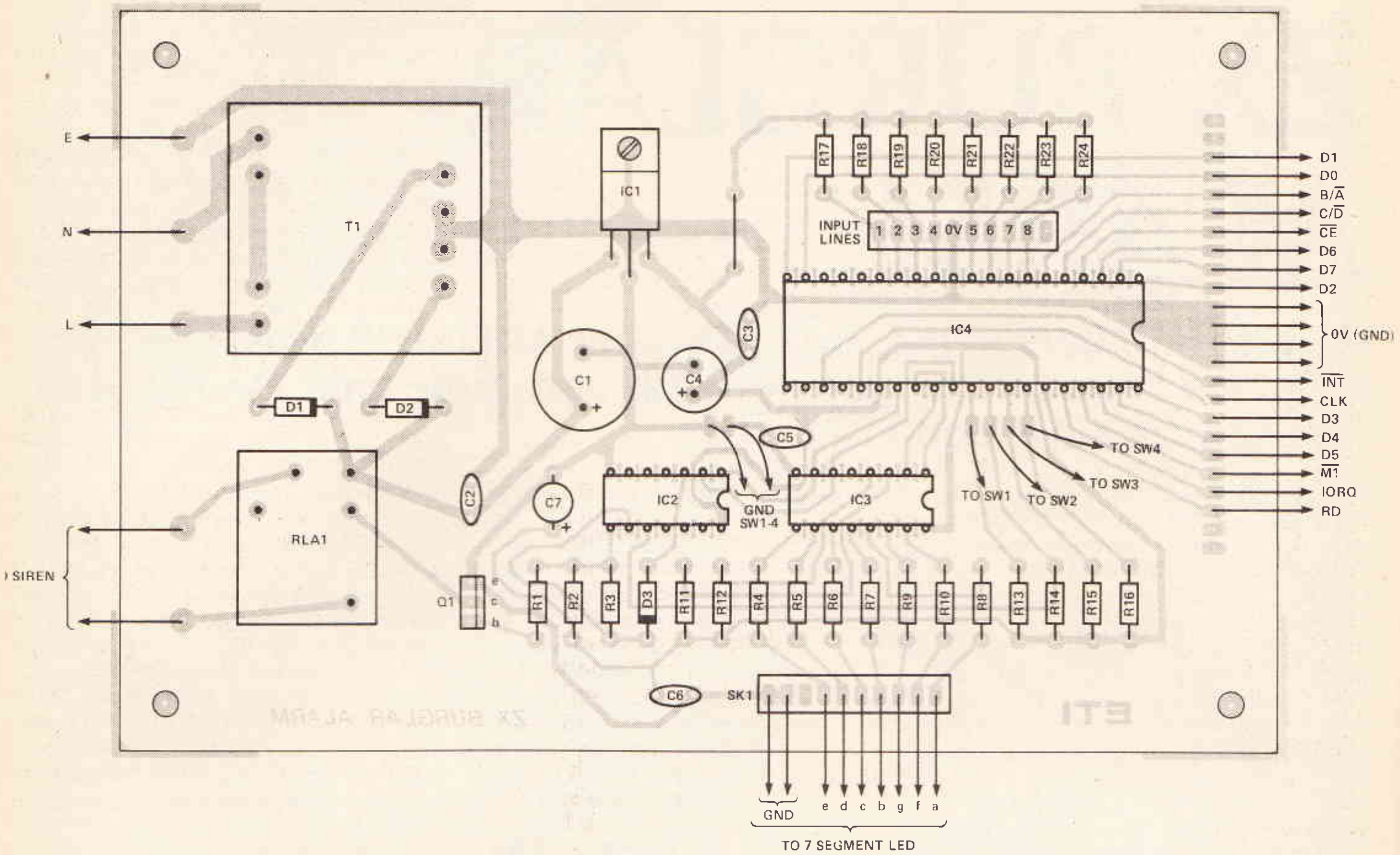


Fig. 2 Overlay diagram of the PCB.

switches respectively). The contents of this register are then continuously compared with the inputs to port A and if any discrepancy is discovered a '9' is sent out to the display. A timing loop, formed by loading a high number into the registers H, L, and then successively subtracting one until the result is zero, ensures that the nine is displayed for at least a second or so, after which the number of the affected input is displayed. An AND gate monitors the A and D data lines into the display driver and thus goes high when the 9 is output, the delay ensuring that it remains high long enough to latch the relay and thus sound the alarm.

Construction

Most of the components, including the relay and the transformer, are mounted on the PCB, the only off board components being the switches, the LED display, the edge connector to suit either ZX81 or Spectrum, and the siren or other output transducer. Make sure that all four ICs are inserted the right way around, and similarly check the electrolytic capacitors C1, C4, and C7, and the diodes. Provision has been made for the use of connectors for the LED display and the input lines but if you prefer you can, of course, solder directly to the board. It is intended that the relay should switch a siren or similar device which draws its power from an

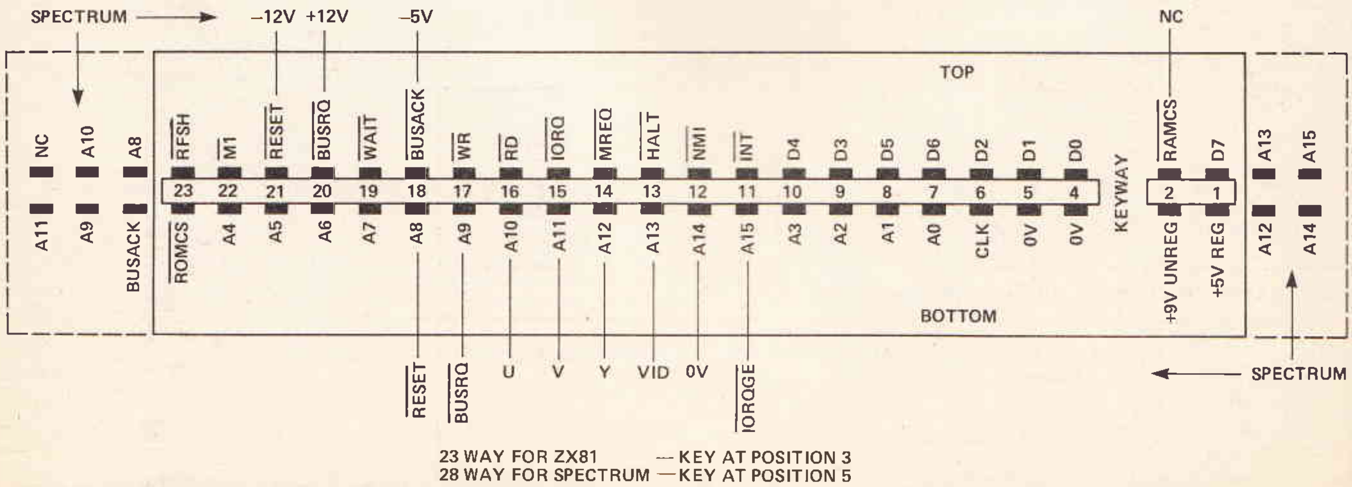


Fig. 3 Pin connections of the ZX81 and Spectrum expansion ports.

PARTS LIST

Resistors (all ¼W, 5%)	
R1	4k7
R2, 4, 5, 6, 7, 8, 9, 10	470R
R3	330R
R11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24	10k
Capacitors	
C1	1000u 16V electrolytic
C2, 3	100n
C4	22u 16V electrolytic
C5, 6	10n ceramic
C7	100u 10V tantalum
Semiconductors	
IC1	7805
IC2	7408
IC3	7447
IC4	Z80A PIO
Q1	BD131
D1, 2	1N4001
D3	1N4148
DISP1	Common anode 7-segment display
Miscellaneous	
T1	9-0-9V 6VA PCB mounting transformer
SW1, 2, 3, 4	momentary action, push-to-make
RLA1	12V DC 400R miniature relay

PCB: edge connector to suit ZX81 or Spectrum; 10-way 0.1" pitch PCB plug and socket — 2 off each; case, etc to suit

BUYLINES

All of the semiconductors, including the Z80A PIO, are readily available from a number of our regular advertisers, as are suitable transformers, ZX81 and Spectrum edge connectors, 7-segment LEDs and the switches. A suitable relay is sold by both Maplin (code YX97F) and Ambit (type OUD), both of whom also supply PCB connectors. The PCB is available through our PCB services, for which see page 74.

external source, eg the mains, but if your particular application does not specifically demand an eardrum piercing, complaint eliciting siren, you might prefer to use an audible warning device of some sort instead. Providing this does not draw more than 100 mA or so and will run from 17V or less, you can connect it directly in the collector circuit of Q1 and dispense with the relay entirely. The edge connector you use to connect the unit to the micro will depend on whether you plan to use a ZX81 or a Spectrum, and should be wired in accordance with Fig. 3.

The choice of case is left entirely to the constructor, but since there is mains on the board it is advisable to have some sort of enclosure. Mounting the switches should present no problems but the LED display is not so easy. If you're after a particularly neat appearance you would perhaps do best to go for an easily cut plastic case, and to cut out an aperture for the LED and then mount it flush in Araldite. The input lines, mains input, and connections to the microcomputer could either be taken through grommets or, if you're really fussy, through appropriate connectors, although it is probably most convenient to use a connector only for the input lines.

Programming

The Z80 PIO ahas six control lines, three of which (MI, IORQ, and RD) can be connected directly to their counterparts on the Spectrum or ZX81 edge connector. The remaining three, B/A SEL (select port A or B), C/D SEL (select either control or data carried on bus), and CE (chip enable) must be connected to the address bus. The Spectrum manual tells us that A0, A1, A2, A3, and A4 are all normally high (they are used to control printer, loudspeaker, etc), so we can leave these high and connect B/A SEL, C/D SEL, and CE to the remaining three lines, A5, A6, and A7 respectively. A5 low selects port A, A5 high selects port B; A6 low selects data (input and output) and A6 high selects control (programming information). A7, the chip enable, is always held low. The resulting eight bit words are shown in Table 1 and their decimal values are 31, 93, 63, and 127 respectively.

We must next initialise the PIO by sending two control words to each port. The first defines which mode and, as we are using mode three, a second must be sent to define which of the eight lines are inputs and which outputs. The format of the operation control word is shown in Table 2, and it will be seen that the relevant control word for ports A and B is 11111111, that is, decimal 255.

The second control word also consists of eight bits, each one corresponding to the I/O line with the same number, ie, bit 0 corresonds to PA (or PB) 0, bit 1 corresponds

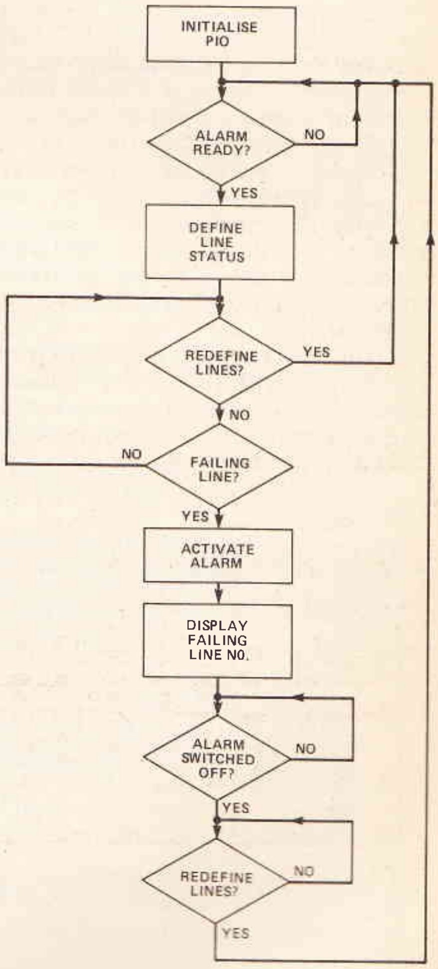


Fig. 4 Flow chart of the burglar alarm program.

A7	A6	A5	A4	A3	A2	A1	A0	PORT
0	0	0	1	1	1	1	1	A data
0	1	0	1	1	1	1	1	A control
0	0	1	1	1	1	1	1	B data
0	1	1	1	1	1	1	1	B control

Table 1 Examples of eight bit PIO address words.

BIT	7	6	5	4	3	2	1	0
output mode	0	0	1	1	1	1	1	1
input mode	0	1						
bidirectional	1	0						
control	1	1						

Table 2 Format of the operation control word.

```
10    Clear 32500
15    For n = 0 to 107 : read b
20    Poke 32500 + n , b
25    Next n
30    DATA   62,  255,  211,  93,  211,  93,
      211,  127,  62,  240,  211,  127,  219,  63,
      203,  111,  40,  -6,  6,  8,  62, 0, 30, 0,
      60,  211,  63,  219,  63,  203,  119,  40,  5,
      203,  127,  32,  -10,  28,  219,  63,
      203,  111,  32,  -6,  203,  11,  16,  -24, 62,  0,
      211,  63,  219,  63,  203,  103,  40,  -46,  219,
      31,  171,  6,  8,  203,  23,  56,  4,  16,  -6,
      24,  -19,  197,  62,  9,  211,  63,  6,  10,
      17,  1,  0,  33,  222,  57,  237,  82,  32,  -4,
      16,  -9,  193,  120,  211,  63,  219,  63,
      203,  111,  32,  -6,  219,  63,  203,  103,  32,
      -6,  24, -96
40    PRINT USR 32500
```

Table 3 The Spectrum program.

```
62, 255, 211, 93, 211, 93, 211, 127, 62, 240,
211, 127, 219, 63, 203, 111, 40, 250, 6, 8,
62, 0, 30, 0, 60, 211, 63, 219, 63, 203, 119,
40, 5, 203, 127, 32, 246, 28, 219, 63, 203,
111, 32, 250, 203, 11, 16, 232, 62, 0, 211,
63, 219, 63, 203, 103, 40, 210, 219, 31, 171,
6, 8, 203, 23, 56, 4, 16, 250, 24, 237, 197,
62, 9, 211, 63, 6, 10, 17, 1, 0, 33, 222, 57,
237, 82, 32, 252, 16, 247, 193, 120, 211, 63,
219, 63, 203, 111, 32, 250, 219, 63, 203, 103,
32, 250, 24, 160
```

Table 4 (Above) The ZX81 data.

LD A	255	62,	255	
out A	93	211,	93	
out A	93	211,	93	
out A	127	211,	127	
LD A	240	62,	240	
out A	127	211,	127	
IN	63	219,	63	
BIT 5		203,	111	
JRZ	-6	40,	-6	
LD B	8	6,	8	
LD A	0	62,	0	
LD E	0	30,	0	
INC A		60,		
out A		211,	63	
IN	63	219,	63	
BIT 6		203,	119	
JRZ	5	40,	5	
BIT 7		203,	127	
JRNZ	-10	32,	-10	
INC E		28,		
IN	63	219,	63	
BIT 5A		203,	111	
JRNZ	-6	32,	-6	
RRE		203,	111	
DJNZ	-24	16,	-24	
LD A	0	62,	0	
out	63	211,	63	
IN	63	219,	63	
BIT 4		203,	103	
JRZ	-46	40,	-46	
IN	31	219,	31	
XOR E		171,		
LD B	8	6,	8	
RLA		203,	23	
JC 4		56,	4	
DJNZ		16,	-6	
JR	-19	24,	-19	
PUSH B		197		
LD A	9	62,	9	
out	63	211,	63	
LD B	10	6,	10	
LD DE	1	17,	1,	0
LD HL	14814	33,	222,	57
SBC HL, DE		237,	82	
JRNZ	-4	32,	-4	
DJNZ	-9	16,	-9	
POP B		193		
LD A, B		120		
out 63		211,	63	
IN 63		219,	63	
BIT 5		203,	111	
JR NZ	-6	32,	-6	
IN 63		219,	63	
BIT 4		203,	103	
JRNZ	-6	32,	-6	
JR	-96	24,	-96	

Table 5 (Right)· Assembler listing of the burglar alarm program.

to PA1, etc. Setting the bit high defines the associated I/O line as an input, while setting it low defines it as an output. Since port A consists of the eight input lines from the various sensing switches, its control word will be 11111111, again, decimal 255. Port B has lines 0, 1, 2, 3 outputting data to the LED display and lines 4, 5, 6, and 7 accepting input data from the push button switches, so its control word will be 11110000, that is, decimal 240.

The first six instructions of the program therefore consist of loading the relevant control word into the accumulator and outputting it to either address 93 or address 127 (see Table 5 and the flow chart, Fig. 4).

The program can be entered directly into the Spectrum, but if you are using a ZX81 you will need to reserve space for the 108 bytes of machine code by moving RAMTOP. To do this type in:

```
POKE 16388,147
POKE 16389,67
NEW
```

and follow each statement with the Newline command. To check that RAMTOP has been moved, type in:

```
PRINT  256*PEEK  16389+PEEK 16388
```

and you should get 17299.

The ZX81 is also unable to deal directly with the negative numbers used in the jump statements. The computer recognises a negative number by checking to see if the most significant bit of the jump operand is high. If so, then this bit represents −128, all other bits retaining their normal values. For example, suppose we wish to enter −6. This becomes −128 +122, or in binary 11111010 (the first digit representing −128 and the remaining seven representing +122). This is the decimal number 250. This can also be calculated from the two's complement rule: the number (6) in binary

00000110

change 0 to 1, 1 to 0

11111001

add 1

11111010

which is again decimal 250. Thus, any number having the form −X can be entered by using the formula 128 + (128−X) which is, of course, simply 256−X.

Having reserved the 108 bytes after RAMTOP in the ZX81, type in:

```
10 FOR N=0 to 107
20 INPUT X
30 POKE 17299+N,X
40 NEXT N
50 PRINT USR 17299
```

then RUN. The computer will then wait for you to type in the 108 numbers given in Table 4. Note that these are the same numbers as those in the Spectrum program except that all the negative numbers have been replaced with their

HOW IT WORKS

The various intruder detecting switches are connected between earth and the eight lines of port A on the PIO. Each of the eight lines is connected to the +5V line through a pull-up resistor, so that when the associated switch is open a logic high level will appear on the input, and when the switch is closed the line will be pulled down to logical low. The latter four lines on port B are similarly connected so that pushing any of switches 1 to 4 takes the associated line low. The first four lines on port B are used for the display output and carry a four bit binary code. This is fed directly to the decoder/driver 7447 and thence to the seven segment display.

When the program is started up it puts out a '1' and then waits for the line to be defined. Taking either line 6 or line 7 on port B low enters a 0 to 1 as desired into register E. Subsequently taking line 5 low initiates a rotate right instruction which moves the entered data one place to the right so that the register is ready to receive the next bit. The microprocessor then outputs a '2' and the process is repeated until register E is full.

The microprocessor then goes into a continuous loop, using the XOR function to simultaneously compare each input line with the corresponding bit in register E. If both bits are at the same level, either both high or both low, the XOR function will produce a 0 output, but if the two bits are at different logic levels the XOR will give a 1. The RLA instruction is used to shift each bit into the carry flag and test for a 1 and if no carry is detected the microprocessor carries on testing the lines.

When a 1 is detected, a nine is briefly sent out via port B to the display. At the same time, a large number is loaded into registers H and L and 1 is successively subtracted until the result is zero. A total of 148,140 machine cycles are needed for this, and the nine is therefore displayed for a full second or so before the microprocessor removes it and displays instead the number of the failed line. The AND gate IC2b has its inputs connected to the A and D lines from port B, and will therefore go high only when a nine is put out. Its output is connected to IC2a, another AND gate, which is wired as a latch. IC2a drives the transistor Q1 which turns on the relay. The other input of IC2a is connected to line 5 of port B, and if SW2 is pressed this line will go low, unlatching the gate and thus turning off the relay.

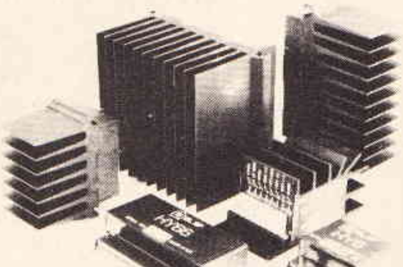
two's complement.

From here on the procedure is the same whichever microcomputer you are using. When the programming has been completed, a 1 should appear on the LED display. This refers to the first line on port A, and you must now tell the computer whether this line is to be high or low, according to what type of sensing switch you plan to use on it. To do this you first press either switch SW3 (LOW) if the line is to be nomally closed or SW4 (HIGH) if the line is to be normally open, and then press the ENTER switch SW2. The LED should now display a 2, and you repeat the procedure with this and each of the subsequent lines.

When all eight lines have been entered and the register is full, the microprocessor goes into a continuous loop, checking each line against its corresponding bit in the register. Should you wish to redefine the normal state of the lines, pressing SW1 empties the register and thus stops the program. If the alarm is triggered, it can be reset by pressing first SW2 and then SW1.

ETI

GET BIG POWER



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HY128	60	8	0.01%	<0.006%	± 35	120 x 78 x 40	410	£20.75
HY244	120	4	0.01%	<0.006%	± 35	120 x 78 x 50	520	£25.47
HY248	120	8	0.01%	<0.006%	± 50	120 x 78 x 50	520	£25.47
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MOS 128	60	4-8	<0.005%	<0.006%	± 45	120 x 78 x 40	420	£30.41
MOS 248	120	4-8	<0.005%	<0.006%	± 55	120 x 78 x 80	850	£39.86
MOS 364	180	4	<0.005%	<0.006%	± 55	120 x 78 x 100	1025	£45.54

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Slew rate: 20v/μs. Rise time: 3μs. S/N ratio: 100db
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Please note: X in part no. indicates primary voltage. Please insert "O" in place of X for **110V**, "1" in place of X for **220V**, and "2" in place of X for **240V**.

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AUDIO DESIGN

Whether or not a preamplifier needs tone controls is controversial; however, what is beyond dispute is that a competent audio engineer needs to know how to design them. John Linsley Hood shows the way.

With the exception of the response curve corrections needed for the proper replay of gramophone records recorded to the RIAA characteristic, so far I have looked mainly at linear amplifier systems, such as the low distortion gain block and the moving coil head amplifier circuits shown in the previous part of this series. What if one wants deliberately to enhance part of the audio spectrum? How does one do it? Well, doing it is easy, but there are some snags, and I think it would be useful to look at these first.

Once upon a time, all proper hi-fi amplifiers had tone controls. Now, most of the very up-market ones don't. Why is that? Being somewhat cynical about the hi-fi scene (and close acquaintance with this field tends rather to encourage this sort of response to the claims, beliefs and motives of those within it), the most immediate answer might be that what you don't put in won't go wrong, nor does the manufacturer have to pay for the bits that haven't been used. A second, less cynical though perhaps more naive thought could be that if you have very up-market gear, the frequency response of all your bits will be so good that any tinkering with the frequency response will be quite unnecessary. The truth, which could include parts of both of the above, would also recognise that one gets nothing for free, and that a beneficial change in the frequency response might also cause problems elsewhere.

Consider first the question of harmonic distortion. As we have seen, this is due to the presence of unwanted harmonics of the signal frequency, so that a 300 Hz signal will be accompanied by unwanted signals at 600, 900, 1200, 1500 Hz, and so on, representing the 2nd, 3rd, 4th and 5th harmonics of the incoming signal. If we give the signal a little treble boost, say +6dB at 1500 Hz, we would have doubled the amount of 5th harmonic present — and this is an unpleasant one, which is quite discordant — as well as increasing the amount of the others present, to greater or lesser degrees. True, the converse also applies. A treble cut will reduce the amount of harmonic distortion, so that, for example, the purity of the sinewave output from an audio signal generator can be improved just by putting a few RC filter elements after its output. Those of us who are old enough will remember the old trick of putting a 0.02μF across the primary of the speaker transformer winding to lessen the amount of third harmonic in the old pentode valve output stages.

At the other end of the frequency spectrum, while a bit of bass boost may help to give a punchy quality to a drum or string bass, or impress your friends by making your doors rattle on an organ pedal note, the penalty could be an enhanced response to mains hum, or rumble from the gramophone turntable or record. More subtly, the penalty might be just that the low frequency signals, because they occur at frequencies where our ears are not very sensitive, tend to be rather large in amplitude, so that a bit of bass boost might make them so big that they actually overload our amplifiers or LS systems. This last is very likely, since LS driver cones tend to move in and out quite a bit at LF anyway, because of the very limited air loading at these frequencies.

So, how about filtering the signal to remove the turntable rumble, or other very low frequency signals for which the LS will tend to flap its cone, before applying the bass boost? Yes, this would be better, but even filtration has snags, tonally. These come about because rates of change of signal amplitude with frequency greater than −6dB/octave (where the signal amplitude halves as the frequency is halved — or doubled) occur very rarely indeed in nature, so our ears respond to higher rates of change as an 'unnatural' sound, or a 'colouration'. As an example of this, if we take a wide band 'white' noise signal, and we modify the amplifier frequency response by a filter having a −6dB/octave characteristic, as shown in Fig 1a, the 'hiss' will sound a bit different, and a bit quieter, but it will still sound uncoloured.

If we increase the filter slopes, as in 1b, and 1c, to −12dB and −18dB/octave, the sound of the hiss will change, and begin to take on a somewhat 'tuned' quality, characteristic of the turn-over frequency The steeper the filter slope, the worse this will be. This is a criticism which has been levelled at the digital recording systems, where the very steep cut, 'brick wall', anti-aliasing, filters needed for this technique, will introduce very heavy colouration. Fortunately, the steep cut filter frequency is sufficiently high that the 'whistly' quality of the sound will be noticeable only to those with young ears.

The moral of this is, I think, that we should use bass or treble boost with discretion, and never more than we need. Similarly, where possible, we should avoid filters having very steep slopes unless these slopes are variable so we can adjust them to give an aurally acceptable result.

Such steep-cut AF filters, used with 'bi-amped' and 'tri-amped' hi-fi LS systems, where the crossover

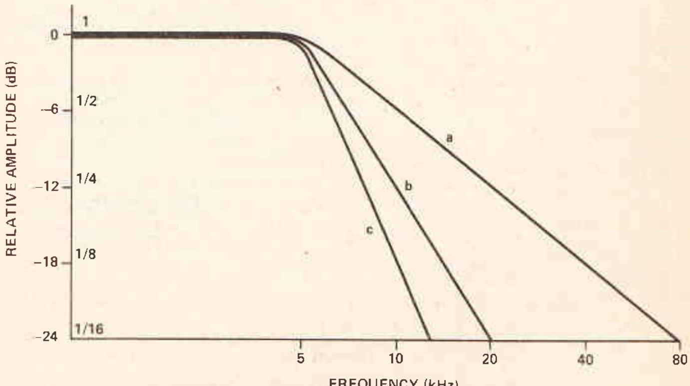


Fig. 1 Effect of different filter slopes.

between wooter, mid-range and tweeter units is accomplished electronically at the input to separate LF, mid-range and HF power amplifier units, can give results which are a lot less good than expected, simply because of the phase changes of the signal and the colouration of the final result. The actual crossover networks in the better commercial LS multi-driver systems tend to owe as much to listening tests and small adjustments to the component values as they do to the initial calculations. These are the snags: now for the circuitry.

Tone Controls

These come in five basic types, each representing an attempt to avoid problems or give better results. These I shall call conventional, shelf, slope, graphic equaliser and parametric types.

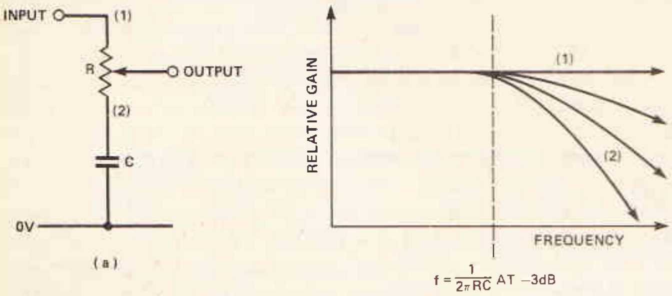
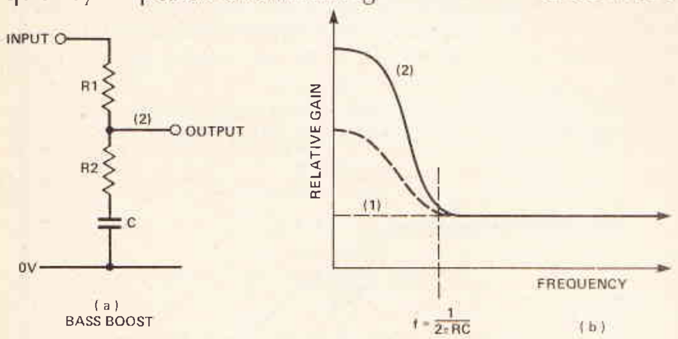


Fig. 2 A very simple treble cut tone control

Conventional Tone Controls

As we have seen, the impedance of a capacitor is related to frequency by the equation $Z_c = 1/2\pi f_c$. This means that the simple RC circuit of Fig. 2a would, if driven by a sufficiently low source impedance and loaded by a sufficiently high output impedance, have an output at (1) as shown in 2b (flat with frequency) and an output at (2) which falls at 6dB/octave with increasing frequency, as shown also in 2b. If R is a potentiometer, the gradient of the slope can be varied according to whereabouts one taps off the output. This will give a simple treble cut 'tone control'. If one modifies the circuit a little, as shown in Fig. 3a, to include a resistor R2, to limit the attenuation when the impedence of C has fallen to a very low value, and if one makes C a lot bigger in value, the output at (2) will rise below a certain frequency, dependent on the component values, to give the frequency response shown in Fig. 3b. This could be made



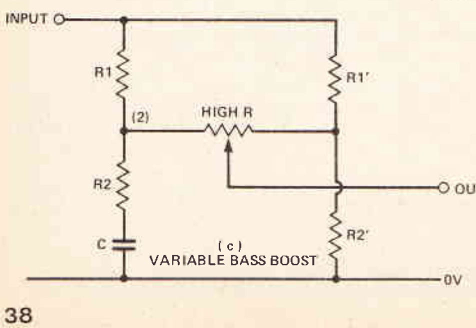


Fig. 3 Simple bass boost circuits.

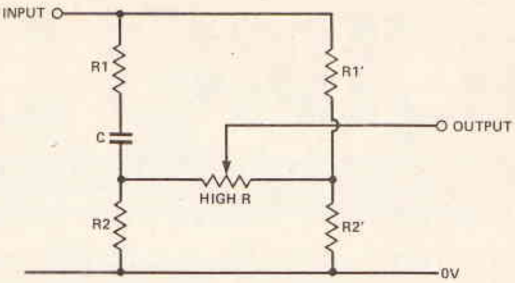


Fig. 4 A simple treble boost (or bass cut) circuit.

into a variable bass boost control by the circuit layout of Fig. 3c.

A similar sort of exercise can be done to make passive (ie, built entirely from Rs and Cs, with no amplifying elements) bass cut and treble lift arrangements, as shown in Fig. 4. Inevitably we will need to work out some means of interconnecting these so that they don't interact, and several such circuits, as for example in Fig. 5, have been worked out, and were popular in the USA. The question is really whether it is worth the bother, when the excellent arrangement first proposed by Mr. P. Baxandall, shown in Fig. 6, will do all that is needed just as well and more neatly.

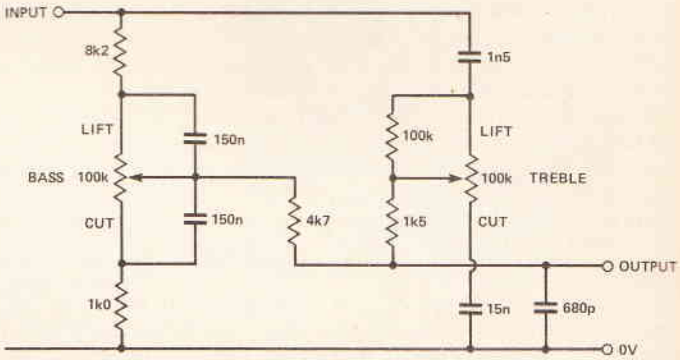


Fig. 5 Typical (commercial) passive tone control circuit.

The big advantage supposedly conterred by passive tone control circuits is that because they only contain Rs and Cs they won't distort the signal. however, they will attenuate the signal — since they only work by selective attenuation, a 20dB 'lift' at one frequency is simply a 20dB attenuation everywhere else in the spectrum. Therefore it is necessary to amplify it by 10 (=20dB) either before or after the passive tone control stage, and this amplifier may distort.

Also, there is the question of where this amplifying stage should be put. If this TC stage has an attenuation of 20dB, and 1 V RMS output is needed from it, a 10 V RMS input signal (at least) is needed for its input — and this is a pretty big signal for a preamp. So — what if the amplifier is put so that it follows the TC stage? Then it only has an output of 1 V RMS, so it will have a reasonably low distortion, but there will be a lot of Rs and Cs connected to its input, which is now at only the 100 mV level, and which makes the task of getting a god S/N ratio, and low background hum level, just that much more difficult.

The Baxandall circuit avoids this difficulty, since, in the flat frequency response position of the controls, it will normally have unity gain, so 1 V out requires 1 V in, which presents few problems in S/N ratio or hum pick-up. The way this circuit works is best explained by the simplified circuit of Fig 7, which is a straightforward negative feedback inverting amplifier, whose gain is R_b/R_a. If $R_b = 10R_a$, then the gain is 10. If $R_b = R_a$, the gain is 1. If

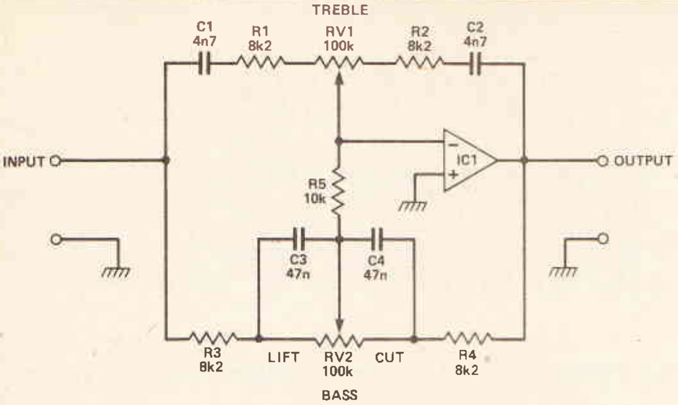


Fig. 6 Typical negative feedback tone control circuit of the Baxandall type.

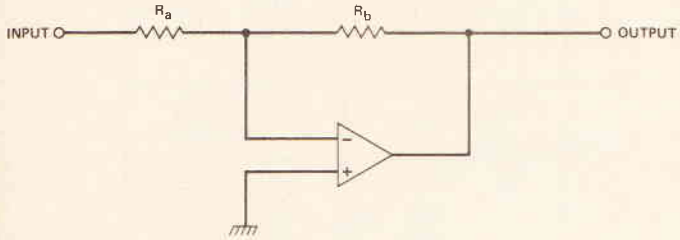


Fig. 7 Simplified feedback circuit.

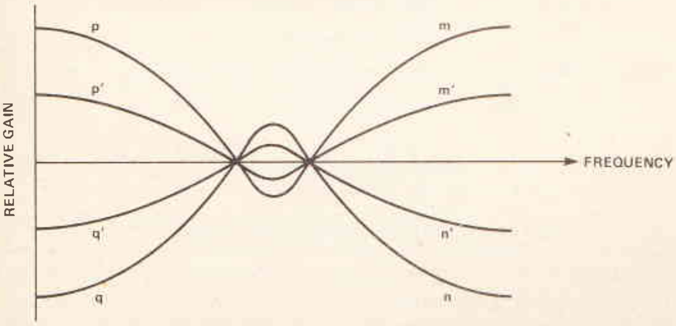


Fig. 8 Behaviour of negative feedback tone control (overlap effects exaggerated).

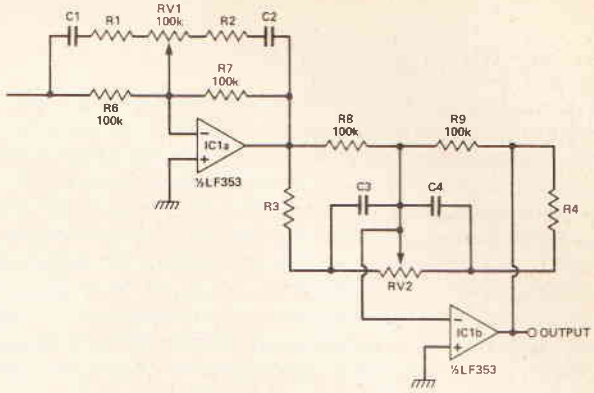


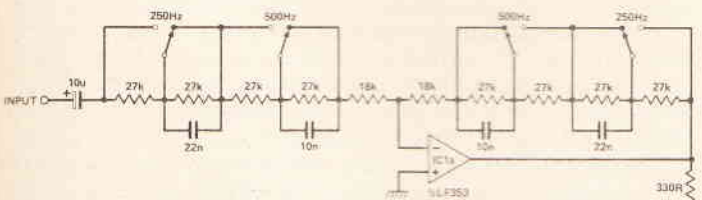
Fig. 9 Sequential two-stage tone control which avoids interaction between controls (component numbering of Fig. 8 retained except for new components R6 and R7 needed for DC feedback, and absence of R5).

$R_a = 10R_b$, then the gain is 0.1, and so on. Referring back now to Fig 6, C1+R1 and C2+R2 are RC combinations whose impedance decreases with frequency. If the setting of RV1 is such that 'R_a' is largely due to C1+R1, then the amplifier will follow the gain curve (m) in Fig 8. If the slider on RV1 is moved to the other end of its travel, so that it is now R2+C2 which is equivalent to 'R_b', then the gain curve will follow the form (n) in Fig. 8.

R3+C3 in Fig 6, is a network whose impedance increases as the frequency decreases, so that, by a similar argument, the curves (p) and (q) of Fig 8 can be selected by appropriately positioning the slider on RV2. The intermediate curves p', q', m' and n' can be selected at intermediate positions of the sliders on RV1 and RV2, with a flat frequency response being obtained, if the components are closely matched, when the sliders of the pots are exactly in the middle of their travel. The resistor R5 serves to help isolate the operation of the 'bass' and 'treble' sections of the tone control. This isolation is, however, always a bit less than perfect, so the perfectionist might prefer to separate out the two halves in two successive stages, as shown in Fig 9, using two halves of a dual op-amp. the limit resistors R1, r*, R3 and R4 in both cases serve to prevent the circuit from trying to give an infinite gain or a zero gain at the extreme potentiometer slider positions.

Shelf-Type Tone Controls

This is a compromise between the Baxandall and Graphic Equaliser type tone control systems, in which a series of RC networks are arranged so that they can give separate 6dB shelves in the frequency response, which can be added (or subtracted) at will, at octave elements in the audio pass band. This gives a very similar type of response correction to that of the graphic equaliser (though more limited in amplitude) but without the snag of the very uneven frequency response which the graphic equaliser will give at max. or min. settings. Provided that only relatively small amounts of correction are needed, this arrangement allows for separate octave band portions of the frequency response to be raised or lowered independently. Typical possible frequency response curves are shown in Fig. 10, and a circuit for this type of tone control is shown in Fig 11.



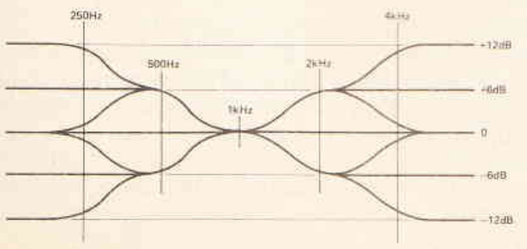


Fig. 10 (LH corner) Typical frequency response curves for two-stage shelf control (desired frequency response can follow any one of these patterns).

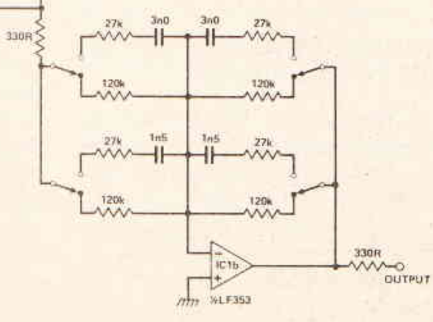


Fig. 11 Circuit layout for two-step shelf-type tone control.

Slope Controls

The realisation that, with good quality audio equipment and good programme sources, the major requirement of the normal user would be to alter the general slope of the amplifier frequency response, to correct a somewhat over dull or over shrill quality in the input signal (the preferences of the original sound engineer may differ from ones own or from any other engineer), led the Acoustical Manufacturing Co., in their Quad 44 preamp., to provide for the skewing of the frequency response, to give an overall upward or downward slope to the response curve, of the type shown in Fig. 12. A typical circuit for this, due to Quad, is shown in Fig. 13.

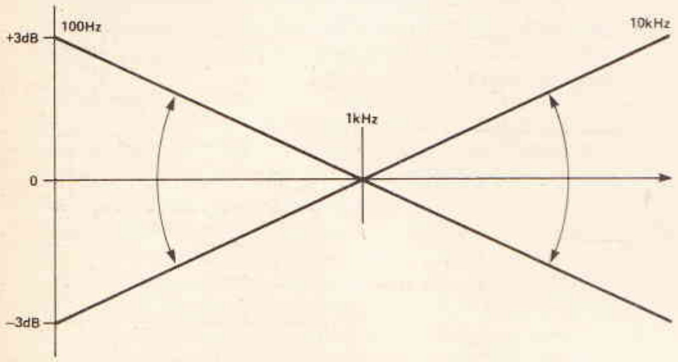


Fig. 12 Slope type tone control.

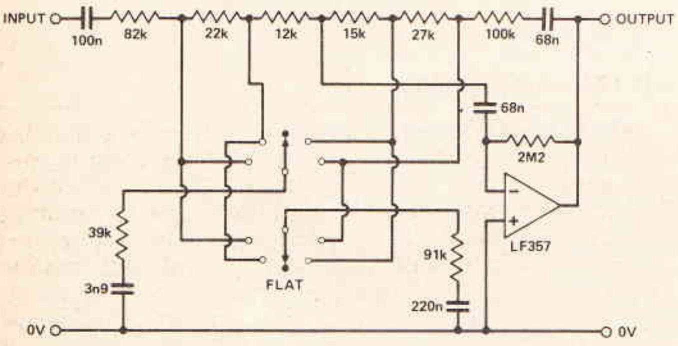


Fig. 13 'Quad' tilt control.

Graphic Equaliser Systems

The basic idea behind this development was a good one, and the scheme enjoyed a considerable popularity when it was first introduced in the early 1970s. In essence, the idea is that in a normal listening room environment, and with normal LS and gramophone PU units, the frequency response of the system — at the ears of the listener — will contain a number of humps and troughs, most of which will probably be quite localised. Therefore, if one could divide up the acoustic spectrum into eight, single-octave chunks — which would cover the range from 60Hz to 15.3KHz — and if some provision were made for adjusting the gain of the preamp, upwards or downwards, in each of these sections, it should be possible to make a pretty fair job of organising a flat frequency response, as actually presented to the listener.

Well, by and large, the system works. The first snags are the obvious ones — that nature does not often oblige by putting its humps or troughs in the frequency response just at the centre frequency points (90, 180, 360, 720, 1440, 2880Hz, and so on) which such an eight octave equaliser would offer, they are just as likely to occur at the interface frequencies where we could do nothing about them. the other snags are those which arise from the nature of the corrected frequency response, of which the possibilities are shown in Fig. 14. These are: with all the controls set to their mid-point positions the frequency response tends to have a corrugated iron appearance; furthermore, if all controls are set to either max. or min. positions, this irregularity is much exaggerated; and all rapid changes in gain vs. frequency are accompanied by very large phase shifts. The sound of a transient (percussive) event is very dependent on the relative phase (= time of arrival) of the sound components which go to make up this event; if one churns up the phase components, one gets some strange effects.

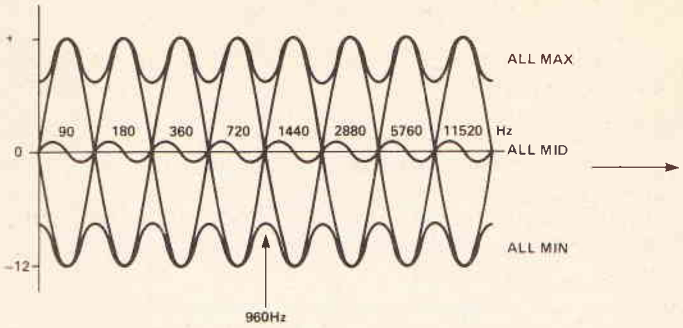


Fig. 14 Response of a graphic equaliser tone control system

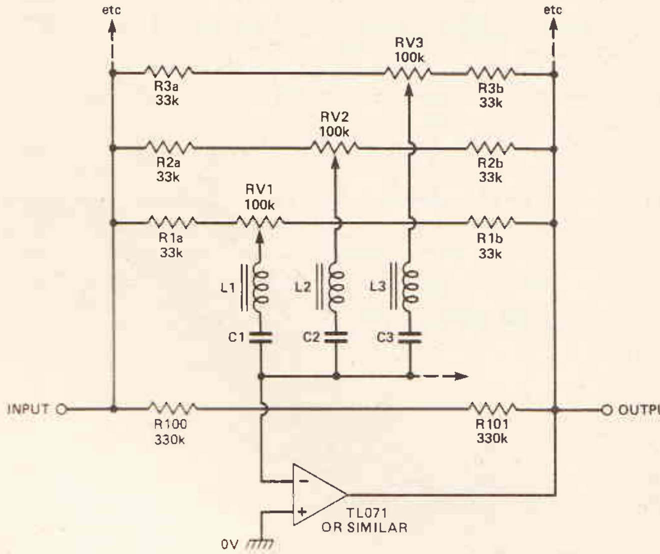


Fig. 15 Circuit arrangement of a graphic equaliser.

So, with a little regret, the consensus of opinion is that such tone correction systems, unless used very judiciously, tend to diminish the realism of the reproduced sound. However, for those who would use such systems judiciously, the circuitry needed is shown in Fig 15.

This operates by utilising the characteristic of a series resonant LC circuit, such as L1/C1, to provide a very low impedance path at its resonant frequency. Left to itself, the op amp, IC1, with R100 and R101, would be a unity gain inverting amplifier. If RV1 is large in relation to the other circuit resistors (R1a, R1b), when the slider of RV1 is at its left hand end, the gain of the circuit (at the frequency at which L1/C1 has a nominal zero (impedance) will be given by: Ein/Eout = R101/(R1a//R100) ("//" means "in parallel with"), which will be higher than unity gain.

If, on the other hand, the slider of RV1 is at its right hand end the gain of the circuit (at resonance of L1/C1) will be Ein/Eout = (r101//R1b)/R100, which could be a good bit less than unity. So, this gives a means of adjusting the gain up or down at specific frequencies determined by the resonant frequency of the LC series network. Other series resonant limbs, L2/C2, L3/C3 etc., can be connected, in parallel, as shown, with little interaction.

The actual resonant frequency of this network can be calculated from the equation $F = 1/(2\pi)LC$, which can be rearranged conveniently as $L = 1/(2\pi F)^2C$, where F is in Hz, C is in farads, and L is in henries. This gives values for L and C for 90 Hz as 3.1 H and 1µF, for 720 Hz as 500 mH and 100nF and so on. The actual value shown on the circuit diagram will give about 12dB lift and cut; more than this would be unwise.

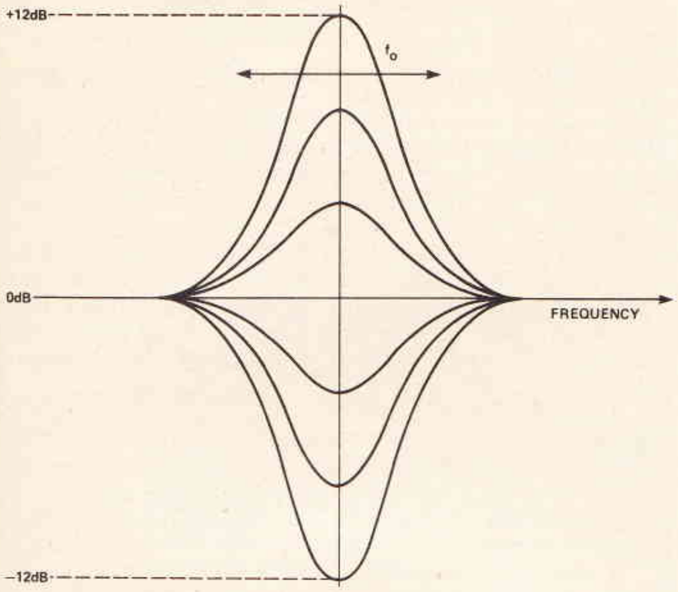


Fig. 16 Parametric tone control response.

Parametric Equaliser Type

This has similarities to that of the graphic equaliser system, but is more modest in its intended scope. In this arrangement, a correction is applied to a single point in the frequency passband (although, in principle, more could be used), and provision is made not only for modifying the amplitude from peak to notch, but also for moving it up and down the frequency spectrum, so that it could be positioned precisely at the point at which a tonal correction is required. Such a system could be made by taking a single section of the circuit of Fig. 15, and altering its operating frequency by adjustments to L1 or C1 by switching, though in the rather complex published circuits the resonant frequency is usually generated by the use of gyrators, which are electronically simulated inductors. The frequency response is shown in Fig. 16.

Impedance Matching

In general, all of these tone control circuits, and most of the other preamp circuits will operate at their best if they are driven from a very low impedance, and loaded with a very high impedance. Most op amps, or gain blocks connected in this manner, will have a low output impedance, due to the operation of the negative feedback system. If they are connected as non-inverting amplifiers they will generally have a high input impedance. If they are connected as inverting stages, the input impedance will be that of the circuit elements connected between the input and the — input connection to the op amp. This will not normally be very high, but will usually be a lot higher than that of an op amp direct output connection. If a tone control circuit is driven from too high an input impedance, the maximum lift available will be lowered, and the interaction between the treble and bass controls will be increased. If an 'active' filter is driven from too high a source impedance it may be unstable.

Filters

All of the RC tone control circuits described above will give a maximum lift or attenuation characteristic of 6dB/octave — associated with a maximum phase shift of 90° beginning at the octave below a treble lift or cut, or at one octave above a bass turn-over point. (this phase shift is not particularly important in tone control systems, but should be remembered as an unavoidable accompaniment of any frequency response adjustment mechanism.) If a greater rate of attenuation is needed, for example for HF whistle removal or for rumble filtering, a wide variety of steep cut filter circuits are available.

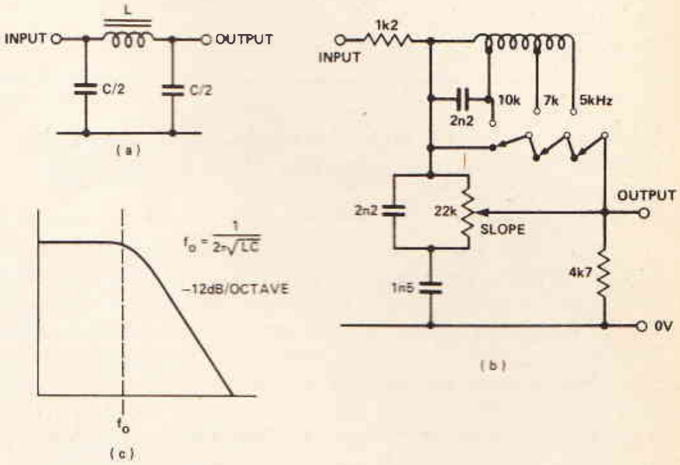


Fig. 17 LC low-pass filter system.

Of these, the simplest is the LC system shown in Fig. 17a. This is quite often used in treble filter circuits, and the arrangement shown in Fig. 17b is the three-frequency variable slope filter of the Quad 33 preamp. Although one could also use this arrangement as a rumble filter, this is not commonly employed mainly because the large values of inductance required would lead to a proneness to hum pick up. To get a good rate of LF attenuation, the Q of the LC network would need to be high. This is determined by the ratio L/CR (where R is the winding resistance of the choke, and its associated core losses), which means that L has to be high, so that the required low frequencies cannot be obtained simply by using a big C.

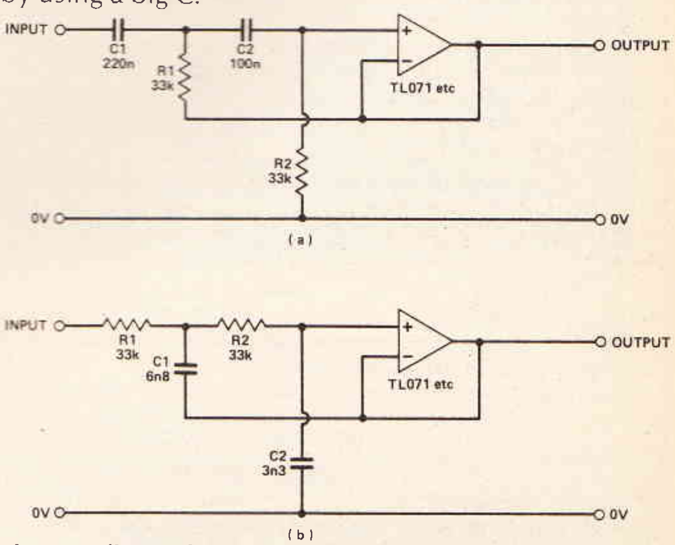


Fig. 18 Sallen and Key active filter circuits: (a) high pass (30 Hz) −12dB per octave; (b) low pass (1 kHz) −12dB per octave.

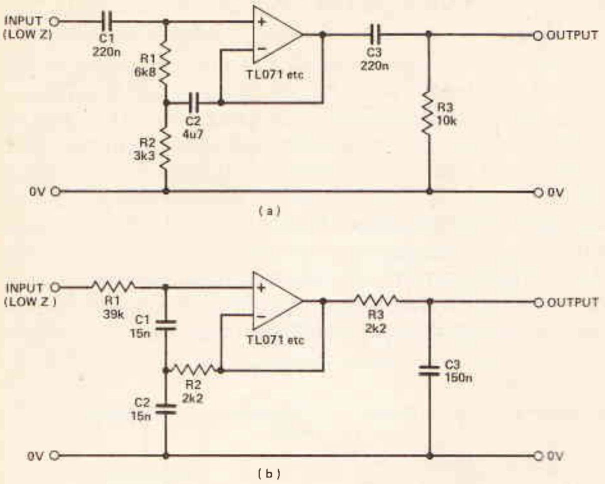


Fig. 19 Bootstrap or H filters: (a) high pass (30 Hz) −20dB per octave; (b) low pass (nominally 1 kHz, actually 1145 Hz) −20dB per octave.

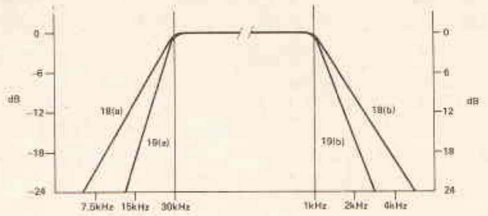


Fig. 20 Filter slopes given by treble and bass filters of Figs. 18 and 19.

More conveniently, active filter arrangements can be used, based on some power amplifying element, such as an op amp, and a group of Cs and Rs. The circuits for active filter arrangements are very numerous, but two of the most useful, which can be built around any suitable op-amp, or even an emitter follower, are the Sallen and Key and the 'Bootstrap' circuits, which I have shown in Figs. 18 and 19 in their respective high-pass and low-pass versions, together with appropriate circuit values for 1 kHz (low-pass) and 30 Hz (high-pass).

This latter value is conveniently placed for a preamp rumble filter, but all of the filter turn-over frequency points can be scaled up or down by proportional adjustments to the values of the resistors **or** the capacitors. One can check the correctness of ones choice from the formula $F_t = 1/2\pi\sqrt{R1R2C1C2}$.

As shown, the Sallen and Key circuits of Fig. 18 will give a −20dB/octave attenuation rate, because they have a three section structure, and one can push the Q up a bit higher. (Other things being equal they would have given −18dB/octave). The slopes obtainable are shown in Fig. 20.

The analysis of these circuits, and the method of calculating their performance is a little beyond the scope of this part of this series, but I will explore this field later, when I take a look at the use of complex numbers in calculating the impedance and phase shifts caused by reactive components in passive and active networks.

In the next part of this series I propose to take a look at audio power amplifiers, to see how these may be designed, and to try to assess the present state of development of these, and how much of the myth has a foundation.

ETI

FINESSE LIGHT CHASER/SEQUENCER

Bored with lights that just flash on and off? Get them to chase around in pretty patterns and mesmerise your friends with the ETI Finesse Light Chaser unit. Design by Ian Benton.

The electronics controlling a disco lightshow is increasing rapidly in sophistication — so here's my attempt to do for the light chaser what ETI's "Spectracolumn" did for the sound to light unit last December. Here's the Finesse Light Sequencer.

This design uses only a similar number of components to the average light controller but provides many more functions, coming a close second in versatility to a fully microprocesor controlled light system. It provides not only the chase/invert/all-flash patterns that are available on the simplest controllers and the forward-reverse chase patterns that appear on some of the more upmarket versions, but a selection of forty different sequences including 10 chase patterns (chase up, chase down, alternate forward reverse, chase in twos, chase in fours etc.) eight flash patterns (all flash, a short strobe-type flash, left & right alternate flashing, centre & outside alternate flashing), and 20 other sequences including chasing from both sides to the centre, etc. and two test sequences (all on and all off). In addition, the unit has both sound-chase and auto-chase facilities so the lights can be set to change in time to the music or at a constant rate determined by a front-panel mounted potentiometer.

The unit can be used to drive all manner of light boxes — certain sequences appear more impressive on different types of display up to a maximum of 375 watts per channel — any more than that and the mains fuse blows when all 8 lights turn on together — the prototype drives a long box with eight spotlights plus two square boxes with eight lamps arranged in a radial pattern.

The various sequences are stored in an EPROM with one byte (8 bits) determining the state of each of eight lamps, and 16 bytes in each sequence so that the display steps through 16 changes of

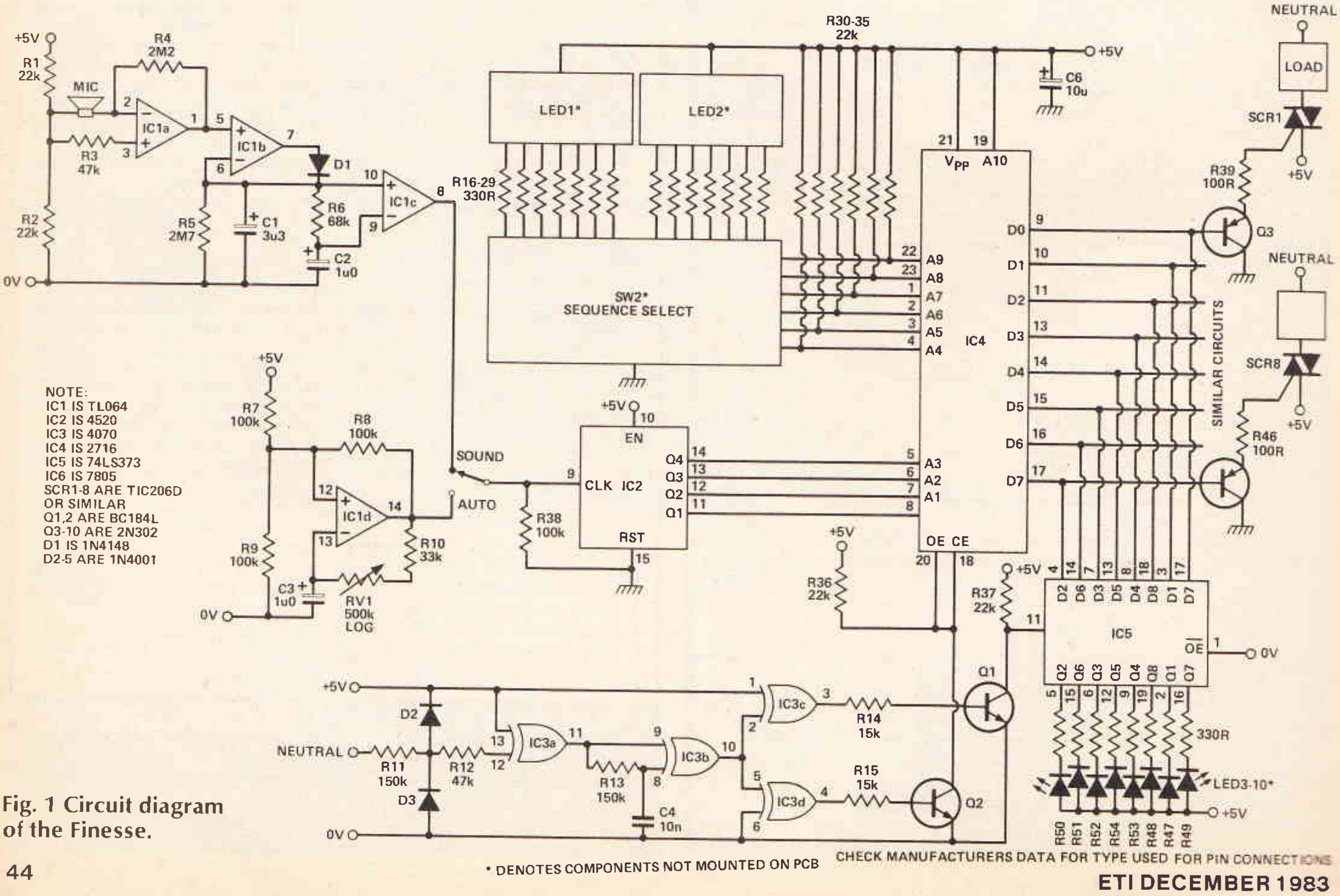


Fig. 1 Circuit diagram of the Finesse.

* DENOTES COMPONENTS NOT MOUNTED ON PCB

CHECK MANUFACTURERS DATA FOR TYPE USED FOR PIN CONNECTIONS lights before it repeats again. The sequences are selected using a 40-way (CB rig type) switch. This produces a BCD output which is connected to address lines A4-A9 (A10 is not used), and a two digit seven segment output which drives a front panel display. As the switch has BCD outputs the addresses from A to F (hex) cannot be used, which limits the system to 40 sequences out of the possible 64.

A 2716 (16K) EPROM was chosen as the data storage device. Although only half the available memory is used it has an advantage of cost over the 8K (2758) EPROM which is now not easily obtainable, and of ease of use over the 2708 which requires in addition a −5V and +12V power supply.

Bipolar (Schottky) PROMs were considered as they are completely non volatile (an EPROM may suffer data loss it gets too close to the disco UVs without an opaque sticky label) but these are far more expensive than the EPROM (£11 for a Schottky PROM compared to about £2.25 for an EPROM) and cannot be erased if you make a mistake during programming — you have to throw it away and start again with a new one. However, it is possible to use a Schottky PROM with a slight change to the PCB: see Modifications section.

The circuit also includes an optional LED display which shows what should be happening at the front. It was decided not to include bulb failure detection as the prototype drives three bulbs in parallel and so would only show a failure if all three bulbs blew which is fairly unlikely.

The completed circuit is split into three sections. The transformer, rectifiers, and reservoir capactor were mounted separately as they were common to another controller which was mounted in the same box as the prototype. Note that no PCB has been given for this section, as it is much cheaper to mount these components separately, either using a piece of Veroboard or point-to-point wiring. Do remember that **all** the PSU components are at mains potential. The sound chase board was kept separate to place the microphone behind the front panel and keep the wires between the speed control potentiometer and the oscillator circuit to a minimum to avoid pickup of unwanted signals causing spurious output pulses.

The sound chase circuit features automatic level control which eliminates the need to adjust a level control. It gives a genuine sound-chase which changes the lights on the beat instead of just varying the speed according to the volume of sound. The circuit has a fast attack and fairly slow decay so it is quite effective at picking out drum beats or cymbals. The circuit includes its own crystal microphone which is of sufficiently high quality for this application as only the general sound level needs to be detected. If you're very fussy, you could use an electret condenser microphone if you can find a 1.5V power supply for its internal JFET amplifier. The sound chase and oscillator circuits are implemented using a TL064 IC (this is the quad low-voltage low-power version of the familiar TL071).

No connection should be made to the disco sound equipment unless it is done through an isolating transformer or opto-isolator as the entire sequencer circuit is at mains live potential.

As an added bonus the circuit features zero-crossing control of the triacs — this eliminates radio frequency interference which is generated if a triac turns on in the middle of a half-cycle and also reduces the current required to trigger the triacs as they are only triggered at the beginning of each half cycle.

The overall cost of the circuit compares very favourably to a commercial unit and even to some of the simplest three channel controllers; the major part of the cost will probably be in the bulbs, bulbholders and connectors.

Construction

Be especially careful when soldering on the PCB as the tracks are very close together in places and both mains live and neutral appear on the same board. Use a good quality socket for the EPROM as you may need to remove it; the other ICs can be soldered directly if you feel confident enough, otherwise use sockets. Take care to get the tantalum capacitors the right way round (they smell terrible when they blow up) as well as the ICs and diodes.

The actual transitor types used are not critical, but the PCB is laid out for the types specified, and you will have to make sure that the right leads go down the right holes.

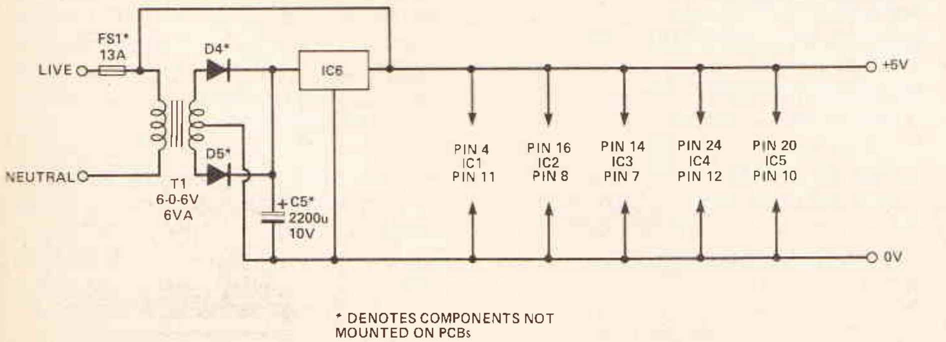


Fig. 2 Suggested PSU circuit.

HOW IT WORKS

The audio signal is picked up by the crystal microphone and amplified by IC1a which has a high gain. IC1b along with D1,R5 and C1 form a peak detector which has a fast atack and slow decay. R6 and C2 follow the peak with a delay, IC1c compares the peak signal with the delayed signal and therefore produces a pulse corresponding to any sudden increase in volume.

IC1d along with R7,R8,R9,R10,C3 and RV1 form a conventional Schmidt trigger oscillator with a speed variable from 0.5Hz to 10Hz. Switch SW1 switches between the Sound and Auto inputs.

IC2 is a four-bit binary counter which counts the input pulses and steps the four low-order address lines of the EPROM though the 16 bytes of the sequence.

SW2 provides the high order address lines and also drives a 7 seg display. The switches are connected between the input and ground to maintain compatibility with bipolar PROMS which require a higher pull-down current which is thus provided through the switch and not the resistors.

D2 and D3 clip the mains 50Hz sinewave and IC3a produces a square wave. This is doubled by IC3b, buffered by IC3c and inverted by IC3d to produce a positive going and a negative going pulse; these are used to enable the EPROM outputs at the beginning of each half cycle and to latch the data into the LED driver (IC5). Q3 to Q10 produce a 50mA pulse to trigger the triacs (SCR1 to SCR8) which turn the lamps on.

The power supply is fairly conventional with a transformer, rectifier diodes, reservoir capacitor and three-terminal regulator. The 5V output is connected to mains live. C6 is a decoupling capacitor for the EPROM supply.

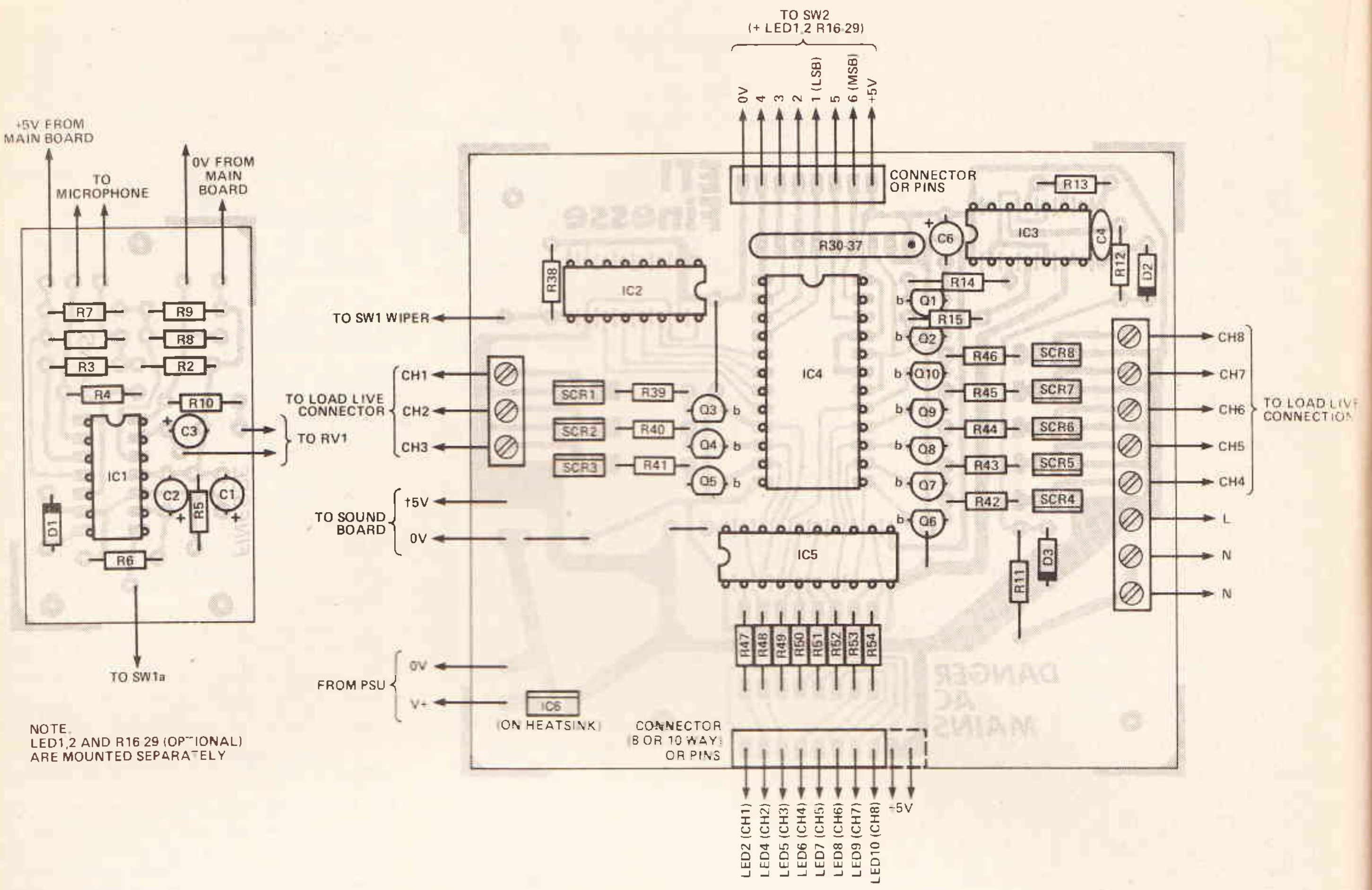


Fig. 3 Overlay diagram for the main board and the sound board (on left).

In particular, note that the pin-out of the BC184L is different from that of the BC184. Note also that IC2 and IC3 face in different directions. All the ICs apart from the TL064 and 74LS373 are MOS so require handling carefully — don't touch the pins more than you have to and make sure that your soldering iron has an earthed bit. The TL064 is JFET and LS373 is bipolar and you can touch them as much as you like!

If your crystal mic is mounted a hole in the front panel, make sure that you use a plastic-bodied type as the metal body is connected to one terminal which will therefore be at live potential.

The TL064 op-amp must not be re-placed by a TL074 or TL084 even though these types are cheaper. The 74/84 only works down to 6V whereas the 64 will operate at the 5V supply used by the rest of the circuit. The EPROM can be the cheapest type available (try Rapid Electronics); this will also be the slowest, but 450ns is still plenty fast enough as the inputs are changing no faster than 20Hz and any access time better than 1 ms is good enough. If you're using your own PCB design or Veroboard (??) then don't swap MT1 and MT2 on the triacs even though it simplifies PCB layout. These are not interchangeable and the circuit won't work with them connected the other way round (I tried it!)

A transformer is recommended for the power supply — even if you omit the LEDs you would still need a very hot resistor or hefty capacitor to provide the 70mA that the EPROM needs.

The triacs are driven by PNP emitter followers; while this simplifies board layout (as no base resistors are required), it confuses things slightly as the triacs are then switched on by a zero output from the EPROM. This isn't such a bad thing as erased EPROMs are full of FFs (all outputs high) so this means that an unprogrammed location turns all the lights off.

The triacs are triggered by a negative gate pulse. In this way less current is required to trigger them on (5mA as opposed to 10mA for a positive going gate pulse). The triggering current is actually 50mA; this is to ensure that the triacs turn on fully as quickly as possible. This is fairly important as lamps can have a turn on surge current of up to 10 times the normal running current and the triac will only cope with this if it is fully turned on.

Connections are made to the main board using "Wafercon" terminals for the mains outputs and Minicon connectors and ribbon cable for the switch and LEDs. These are more reliable than soldering to the PCB as movement can easily break a solder joint. (Minicon & Wafercons are from MAPLIN).

The seven segment displays can be either common anode or cathode. The circuit diagram shows the common anode variety with the common display terminal connected to 5V and the switch common to 0V. For common cathode displays simply reverse these two connections.

The CB rig switch (SW2) comes from Ambit, their catalogue shows two types along with a connection diagram. One type produces a BCD output which is one less than the number displayed on the 7 segment displays — for this application, this is immaterial. The displays were mounted on a scrap

PARTS LIST

RESISTORS (all ¼W 5% except as indicated)

R1,R2	22k
R3,R12	47k
R4	2M2
R5	2M7
R6	68k
R7,R8,R9,R38	100k
R10	33k
R11	150k ½W
R13	150k
R14,R15	15k
R16-R29,R47-R54	330R (22 off)
R30-R37	22k x 8 SIL resistor
R39-R46	100R (8 off)
RV1	500k log

CAPACITORS

C1	3µ3F 6V3 tant
C2,C3	1µF 6V3 tant
C4	10nF Siemens PCB polyester
C5	2200µF 10V Electrolytic
C6	10µF 6V3 Tantalum

SEMICONDUCTORS

IC1	TL064
IC2	4520
IC3	4070
IC4	2716 450ns EPROM
IC5	74LS373
IC6	7805 1A 5V regulator
D1	1N4148
D2,D3,D4,D5	1N4001
Q1,Q2	BC184L
Q3-Q10	2N3702 (8 off)
SCR1-SCR8	TIC206D (8 off)
LED1,2	Seven segment LED displays (see text)
LED3-10	single LEDs to choice

MISCELLANEOUS

T1	6-0-6 V 6VA
SW1	SPDT switch
SW2	Rig Switch — see text
FS1	13A fuse & holder

PCBs; lightholders; connectors to suit; IC sockets as required; crystal microphone

SEQUENCE	ADDRESS	CODE															
40	1460	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
39	1470	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
38	1480	00	FF	00	FF	00	FF	00	FF	00	FF	00	FF	00	FF	00	FF
37	1490	FF	00	FF	00	FF	00	FF	00	FF	00	FF	00	FF	00	FF	00
36	14A0	FF	FF	FF	00	FF	FF	FF	00	FF	FF	FF	00	FF	FF	FF	00
35	14B0	F0	0F	F0	0F	F0	0F	F0	0F	F0	0F	F0	0F	F0	0F	F0	0F
34	14C0	F0	FF	0F	FF	F0	FF	0F	FF	F0	FF	0F	FF	F0	FF	0F	FF
33	14D0	C3	3C	C3	3C	C3	3C	C3	3C	C3	3C	C3	3C	C3	3C	C3	3C
32	14E0	AA	55	AA	55	AA	55	AA	55	AA	55	AA	55	AA	55	AA	55
31	14F0	AA	FF	55	FF	AA	FF	55	FF	AA	FF	55	FF	AA	FF	55	FF
	1500 - 156F	FF															
30	1560	7F	DF	BF	EF	DF	F7	EF	FB	F7	FD	FB	FE	00	FF	00	FF
29	1570	7F	5F	57	55	54	50	40	00	80	A0	A8	AA	AB	AF	BF	FF
28	1580	7F	DF	F7	FD	FE	FB	EF	BF	7F	DF	F7	FD	FE	FB	EF	BF
27	1590	7F	5F	57	55	45	05	04	00	80	A0	A8	AA	BA	FA	FB	FF
26	15A0	7F	DF	F7	FD	BF	EF	FB	FE	7F	DF	F7	FD	BF	EF	FB	FE
25	15B0	FC	F3	CF	BF	00	FF	00	FF	3F	CF	F3	FC	00	FF	00	FF
24	15C0	E7	C3	81	00	18	3C	7E	FF	E7	C3	81	00	18	3C	7E	FF
23	15D0	E7	C3	81	00	81	C3	E7	FF	E7	C3	81	00	81	C3	E7	FF
22	15E0	E7	C3	81	00	18	3C	7E	EE	7E	3C	18	00	81	C3	E7	FF
21	15F0	7E	BD	DB	E7	E7	DB	BD	7E	7E	BD	DB	E7	E7	DB	BD	7E
	1600 - 165F	FF															
20	1660	7E	BD	DB	E7	7E	BD	D8	E7	7E	BD	DB	E7	7E	BD	DB	E7
19	1670	F0	0F	F1	8F	F3	CF	F7	EF	F0	0F	F8	1F	F0	3F	FE	7F
18	1680	7F	FE	BF	FD	DF	F8	EF	F7	7F	FE	BF	FD	DF	FB	EF	F7
17	1690	7F	FE	BF	FD	DF	F8	EF	F7	7F	FE	BF	FD	DF	FB	EF	F7
16	16A0	0F	87	C3	E1	F0	E1	C3	87	0F	87	C3	E1	F0	E1	C3	87
15	16B0	3F	0F	03	00	C0	F0	FC	FF	3F	0F	03	00	C0	F0	FC	FF
14	16C0	3F	CF	F3	FC	3F	CF	F3	FC	3F	CF	F3	FC	3F	CF	F3	FC
13	16D0	FC	F3	CF	3F	FC	F3	CF	3F	FC	F3	CF	3F	FC	F3	CF	3F
12	16E0	77	BB	DD	EE	77	BB	DD	EE	77	BB	DD	EE	77	BB	DD	EE
11	16F0	EE	DD	BB	77	EE	DD	BB	77	EE	DD	BB	77	EE	DD	BB	77
	1700 - 175F	FF															
10	1760	7F	F7	BF	FB	DF	FD	EF	FE	7F	F7	BF	FB	DF	FD	EF	FE
9	1770	7F	3F	1F	0F	07	03	01	00	80	D0	E0	F0	F8	FC	FE	FF
8	1780	FE	FC	F8	F0	E0	C0	80	00	01	03	07	0F	1F	3F	7F	FF
7	1790	7F	3F	1F	0F	07	03	01	00	FF	7F	3F	1F	0F	07	03	01
6	17A0	FE	FC	F8	F0	E0	C0	80	00	FF	FE	FC	F8	F0	E0	B0	A0
5	17B0	7F	BF	DF	EF	F7	FB	FD	FE	FE	FD	FB	F7	EF	DF	BE	7F
4	17C0	FC	F9	F3	E7	CF	9F	3F	7E	FC	F9	F3	E7	CF	9F	3F	7E
3	17D0	7E	FE	FC	FD	F9	FB	F3	F7	E7	EF	CF	DF	9F	BF	3F	7E
2	17E0	7F	BF	DF	EF	F7	FB	FD	FE	7F	BF	DF	EF	F7	FB	FD	FE
1	17F0	FE	FD	FB	F7	EF	DF	BF	7F	FE	FD	FB	F7	EF	DF	BF	7F

ALL REMAINING LOCATIONS - FF

Table 1 Suggested EPROM contents.

piece of veroboard which was fixed to the front panel, and the interwiring between the displays and the switch was done using the 330 R resistors and insulating sleeves. The switch is intended to be PCB mounting but was used mounted on the front panel and connections were made by soldering wires to the tags.

The rectifier diodes and capacitor were mounted on another piece of veroboard fixed next to the transformer.

Both outputs from the sound-chase/oscillator board are taken to an SPDT switch, from which the common terminal goes to the clock input on the main PCB. 5V and 0V power supply wires are taken from the main PCB to the sound-chase/oscillator board. All the inter-PCB connections are shown on the diagram. The use of D-type sockets to connect the lights to the controller box is not recommended — you may get a nice display of pyrotechnics as the wires touch together but the triacs will blow faster than any fuse in the circuit and remove the tracks from the PCB. Use larger sockets as the McMurdo types which also have a retaining clip.

Setting-up

There are no adjustments to be made to the circuit — just connect to the mains (carefully), stand well back and switch on. If you get a flash of light from the PCB then you had a short circuit and now your probably haven't much of a PCB left. On the other hand, if nothing happens first check that the switch is not set to 40 (this is all light off). If there are still no lights, check that there is 5V on

BUYLINES

The rig switch is available from Ambit; the suggested connectors are available from Maplin (although substitute types could be used); shop around for the EPROM and buy the cheapest you can find — Rapid should be worth a look; and the PCB is available from our very own service.

the ICs — pins 24 and 12 on the EPROM 16 and 8 on the 4520, 14 and 7 on the 4070 or 4 and 11 on the TL064. If not suspect a bad connection or faulty voltage regulator. Check also that there is a 50Hz high mark/space ratio waveform on pins 18 and 20 of the EPROM — if not check round the 4070.

When all is working, play a record with a strong beat and check that when the SPDT switch is on 'sound' the lights change with the beat and that the lights change at a constant rate adjustable by RV1 when the SPDT switch is set to 'auto'.

When poking around with your 'scope/multimeter, don't forget that the circuit is at live potential, better still, use an isolating transformer. (It's a good idea to keep one hand behind your back all the time — this considerably lessens the likelihood of receiving a fatal shock).

Make sure that you don't put the sequence switch too close to the microphone otherwise the unit will respond to the clicks made by the switch when you change the sequence, and, as these are quite loud the unit will take a couple of seconds before it starts sound-chasing again — this is due to the slow decay on the soundchase circuit.

EPROM Programming

Each sequence lasts for 16 bytes, a zero corresponds to on and 1 to off hence EC (hex) = 11101100 (binary) = lights 1,2 and 5 on, lights 3,4,7 and 8 off.

The starting address is 16 times the 1s complement of the output from the switch (see PROM dump if confused). This is because the switch is connected between the address line and 0V with a pull-up to 5V so that the output of the switch is inverted. This is to maintain compatibility with Schottky PROMS on which the address lines can be pulled up to 5V with a much higher value/resistor than down to 0V.

Modifications

Here is a list of possible enhancements:

1. Using a Schottky (fusible link) PROM. The type required is 875191. A slight modification has to be made to the PCB. Cut the track that connects pin 18 to pin 20 on the EPROM and connect pin 18 to pin 19 (a good big blob of solder will do).

2. Using the rest of the memory. Address line A10 is normally tied to 5V. This means that only the top 1024 bytes of memory are used (from 400 hex to 7FF hex). To use the other 1024 bytes cut the track between pins 19 and 21 on the EPROM and connect pin 19 to a SPDT switch which can connect pin 19 to either 0V or 5V (don't leave it floating). This is slightly more tricky on the bipolar PROM as A10 is pin 21. Cut the track at both sides of pin 21 and connect pins 18/19 (you connected them together above) to 5V. Connect the switch (as above) to pin 21.

3. If you want to use more than 375 Watts per channel: (a) Use heatsinks for the triacs, or if you are using spotlamps, use TIC226D instead; (b) Reprogram the EPROM so that the number of lights on at any one time cannot exceed 3000W (otherwise you'll blow the mains fuse).

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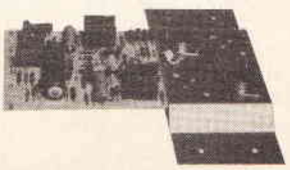

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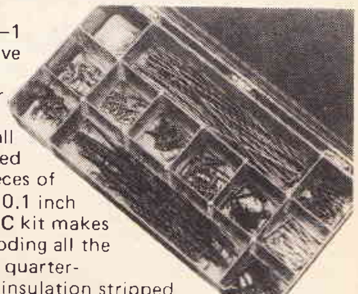

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TOMORROW'S TOOLS TODAY

REVIEW : ALTAI CAPACITANCE METER

Do you ever need to check capacitance? Vivian Capel reviews a meter that takes the misery out of measurement

Who wants to measure capacitors? Many amateur electronic enthusiasts and some professional technicians too, go through life without making a single measurement of capacitance and seem little the worse for it. After all, if you suspect a capacitor in a circuit, you just change it, if the fault clears well and good, if it doesn't you look elsewhere.

Capacitors can be the most troublesome of the passive elements in any circuit — surpassed only by connectors and dry joints as a source for trouble. You may even find it well worthwhile to check all new capacitors as a matter of routine — particularly when prototyping, when it is important to rule out possible sources of malfunction at an early stage.

There are many other situations where capacitance measurement can be very helpful, if only it was as quick and straightforward as measuring resistance. The answer is to invest in a direct reading capacitance meter. There are a few models about, although they are not as common as the bridge. One of the latest to appear is the ALTAI DM-6013, supplied by Semiconductor Supplies International Ltd., 128/130 Carshalton Road, Sutton, Surrey, at a cost of £49.50 plus VAT.

A Closer Look

The Instrument is housed in a plastic case sized 7x3¼x1½ inches, which feels sturdy to handle, not like some instrument cases. It can be supported on the workbench at an angle by means of a pull-down stand at the back.

It doesn't take that close a look to see that the display is a digital LCD read-out giving half-inch high figures. Now I am not over-enthusiastic about LCD displays in spite of their power economy, as the readability is not always what it should be. I have no grumbles with this one though, the 3½-digit read-out comes with bold black figures against a silver-grey background. I found it readable from most angles and in poor light.

A striking feature of the meter is its range. It will measure from 0.1 pF up to 2000µF, which when you think about it is a staggering ratio of $1 : 2^{10}$. The low end of this range does permit some interesting experiments in circuit stray-capacity.

The eight individual ranges are selected by interlocking push-buttons arranged down the left-hand side of the instrument. These advance in value in increments of ten, from the lowest at 200 pF to the highest 2000µF. Resolution is from 0.1 pF at the lowest range to 1µF at the highest.

Specified accuracy is 0.5% on all ranges except the highest for which it is 1.0%. If at any time the accuracy falls outside of those tolerances, the instrument can be recalibrated by the user by means of an internal preset and a capacitor of known value, preferably a large value near the maximum for the particular range.

The instruction booklet describes how to do this, but owing to the inherent stability of the LSI circuitry it should rarely be necessary. If much hard use is envisaged though, it might be prudent to anticipate recalibration, by selecting a suitable capacitor with a low temperature coefficient and recording its measured value with the new instrument. This could subsequently be used as the standard for accuracy checks and recalibration.

Apart from the range switches the only other controls are the on/off switch and a set-zero knob. This latter was the cause of some initial disappointment as I imagined having to fiddle with it each time a range was changed or a measurement made. I was relieved to find I was wrong, as this would have been as irksome as finding the null on a bridge. The control has an adjustment range of ±20pF and therefore is significant only on the bottom two ranges, especially the lowest. Its purpose is to cancel the capacitance of the test leads when making low capacitance measurements.

The instrument applies a small excitation voltage of 2.8V maximum to the capacitor under test. The bottom five ranges function on a fequency of 800 Hz, but for the

higher ranges, the frequency is lowered to 80 Hz (200μF range) or 8 Hz (2000μF). Sampling of the capacitance takes place every half-second, so any variations change the read-out at this rate.

Polarity of electrolytic and tantalum capacitors must be observed, this being indicated by the colour of the leads and sockets (red and black). It is essential to discharge any capacitor before connecting it to the meter, otherwise damage could be caused: there is a 200 mA fuse at the input, but it is wise not to rely on this.

Powering is by a PP3 battery which lasts for 100 hours operation or 200 hours in the case of an alkaline type. When the battery voltage falls to 6.7-7.0V, the legend "LOBAT" appears in the top left-hand corner of the LCD display. When this happens there is still some 20% of the battery life left and several hours use, so this is in the nature of an early warning rather than an instruction for immediate replacement. It shouls not be used for too long beyond this though, otherwise the accuracy will fail with subsequently falling voltage.

In Use

How then did it perform? A good capacitor gave a stable reading within a couple of seconds of being connected. The zero setting on the lowest range was rather touchy, but this is to be expected when dealing in tenths of a picofarad. Movement of the test lead or even one's hand can give a change of capacitance.

On my first introduction to the instrument I felt it was a pity not to have included a leakage test. However, after using it to measure quite a number of capacitors of various types and sizes I found that there is, in fact, a way of testing for leakage. Digit rounding apart, leaky capacitors will give higher readings on the higher range(s) than on the lower. Large leakages (and dead shorts) will return the over-range "1" reading on all ranges.

I also noticed that some capacitors did not give a stable reading, usually yielding a slowly increasing one. Whilst this is not that bad a behaviour for an electrolytic (typical tolerance −50% or +100%), it is bad news for an unpolarised type, and resulted in a fair number of my stock capacitors being consigned to the bin! Also ditched was a smaller number that gave a continual up and down variation.

Lead Testing

A job that I discovered I could do with the test meter was to find the approximate position of an open circuit in a faulty audio lead, so easing the job of repair (OK, I know that if it's gone O/C once, it's likely to go again somewhere else, and the best thing to do is to dump it, but there are occasions when this isn't possible . . .).

When a connecting lead goes O/C, it is almost always near the connector, because there is more flexing there. But at which end? Well it's easy enough to tell with the meter — simply check the inter-conductor capacitances at both ends (ie. centre to screen); the end with the lower capacitance is the one with the fault near it. In the rare event of a break near the midle, this will show up as approximately equal to the ratio of the two lengths to the break.

Conclusion

This is an excellent instrument which does its job well, and which you tend to use more and more until you wonder how you managed without it. It is accompanied by a well-written and informative instruction booklet that contains much useful data including a table listing the various types of capacitor and their characteristics.

ETI

MODULAR PREAMPLIFIER

If walls had ears. . . they'd certainly appreciate ETI's audio building blocks. Barry Porter surveys the ground and comes up with a few plans.

Pre-amplifiers come in all shapes and sizes, yet all are designed to perform the same basic function — to select the output of a given signal source and apply it to a power amplifier at a level that can be adjusted to give the required power output.

It is evident that no pre-amplifier on the market satisifies everyones requirements. Some people must have tone controls while others will not entertain them at any price. Some want moving coil cartridge inputs, others do not . . . What is really required is a pre-amplifier that can be constructed to suit individual needs — a sort of audio Lego kit!

After much deliberation it was decided to design just such a unit, using a mother board system with the active circuitry on individual plug-in boards. This makes it possible to build a pre-amplifier to virtually any configuration by just changing the mother board, which consists primarily of busses and interconnections between the boards carrying the signal circuits.

To make this system as flexibile as possible, the individual building blocks have been broken down into the following categories:-

1. Disc amplifier (Moving coil or magnet)
2. Unbalanced output stage (With provision for active balance control)
3. Balanced output stage
4. Tone Controls
5. Headphone Amplifier
6. Muting Relay Control
7. Power Supply

The first pre-amplifier to be described will use units 1, 2, 6 and 7, so a description of these circuits will be given first, followed by details of how to link them together to make a pre-amplifier that will out-perform many manufactured units that cost the proverbial arm and a leg.

It will be noticed that all signal circuitry is based on the use of operational amplifiers, and as this may raise a few eybrows, a short sermon in defence of this practice is called for. . . In the eary days of integrated circuits, there was created a device known as the 741. Although this humble chip performed well at low frequencies, its limitations at the upper end of the audio spectrum rightfully gained it a reputation for sonic nastiness. Fortunately, progress and evolution have been quite active, and about five years ago a far superior device emerged. Called the 5534, this quickly became the standard IC of the professional audio industry, which consumed them in great quantities. So it is safe to assume that any recent recording has passed through quite a number of these devices — as many as two or three hundred in the case of a multi-tracked original — so no excuses are offered for using a few more in the reproduction chain.

Perhaps comment should be passed on one or two other practices. Following a recent discussion with Martin Colloms, the author carried out some tests which showed that certain types of capacitor can degrade the sound of audio circuits. In particular, the common polyester types proved to be unsatisfactory, as did the standard type of aluminium electrolytic, especially when used without a defined polarizing voltage. For this reason, all small value capacitors should be either polystyrene or polycarbonate (polypropylene are marginally better than polycarbonate, but are difficult to obtain, expensive and very large in size) and the interstage and feedback shunting elecetolytics should be of non-polarized

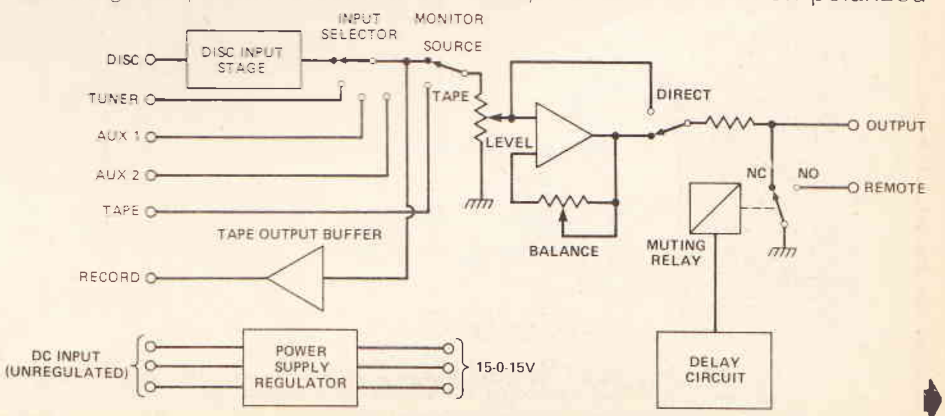


Fig. 1 Block diagram of the basic preamplifier.

construction and should be paralleled with a smaller value polycarbonate, which helps to flatten the high frequency impedance curve.

With that little lecture out of the way, we come to the design of the pre-amplifier, shown in block diagram form in Figure 1. It consists of a disc amplifier stage which may be for moving coil or moving magnet cartridges, input selector switch, level control, active balance control stage and muting circuit. A switch marked 'Direct' may be used to bypass the balance stage, so that if a source with sufficient output capability, such as a Compact Disc player, is connected to an auxiliary input, it may be routed to the power amplifier with only the ganged level control in it's path. When the balance stage is in circuit, the input sensitivity of the tuner and auxiliary inputs is 200 mV for 1.0 V output. The input sensitivity of the disc amplifier can be set to match the cartridge in use, and the input loading may be set to any suitable value of resistance and capacitance. The overload margin of the disc stage is 32dB at all frequencies which should be ample, even with the hot cuts that are sent to annoy us. On tuner and auxiliary there will be no overload problems, as the level control is placed in front of the active circuitry. A note of warning here though — it has been found that the best value of level control is 10k ohms, as this is not likely to cause problems when the direct path is used. Unfortunately, some equipment requires a greater load than this for correct operation, so the choice of level control value should be made with due consideration to this.

Now to the individual circuits that are to be used, starting with the most critical which, of course, is also the most difficult to design and engineer.

Disc Amplifier Stage

In simple terms, this circuit has to amplify the output of a pick-up cartridge to a higher, more manageable level, and at the same time apply equalisation to the RIAA standard, this being defined by three time constants: 3180 μs and 75 μs (corresponding to 50.05 Hz, 500.5 Hz and 2.122 kHz).

The amount of amplification will depend upon the output voltage of the cartridge in use, moving coil types typically requiring some 20-25 dB more gain than moving magnets. To give some idea of the magnitude of the problem, a moving coil cartridge with a nominal output of 0.2 mV at 1 kHz requires amplification by more than 9000 at 20 Hz to give 200 mV at the amplifier output. The RIAA equalisation curve which, relative to 1 kHz, rises to +19.27 dB at 20 Hz and drops to −19.62 dB at 20 kHz, may be obtained in a number of ways. Active feedback around a single amplifier stage is the most popular — possibly because it gives a good specification on paper, particularly in respect of overload margin, which is constant with frequency. This configuration has some drawbacks, usually caused by the amplifier output stage having to drive the very capacitive feedback network. Another type of circuit that has become quite popular uses a passive network between two stages of amplification. Subjectively, this method proved quite successful, but it suffers from inferior noise performance and greatly reduced high frequency overload characteristics.

The circuit to be described may be termed a 'hybrid', in that it has part active and part passive networks. In order to keep noise to a minimum when using a moving coil cartridge, the technique of forming the input stage from several transistors in parallel has been employed. The LM394 integrated circuit contains 100 individual devices divided into two sets of 50 each. By joining the connecting leads of each set together, all 100 transistors are used. When the circuit is operated with a moving magnet cartridge, the LM394 can be replaced by a similar dual device containing a pair of normal, bi-polar transistors. Not only does this help the economics, it should also be quieter as a better impedance match is likely.

Figure 2 shows the complete disc input circuit, and Table 1 gives the component changes necessary in order to adjust the input sensitivity to allow operation with a wide range of cartridges. The input components, R1 and C1, should be chosen to accurately load the cartridge in use, but as a general rule should be 100R and 22n for moving coil cartridges and 47k and 220 pf for moving magnets.

The operation of this circuit is quite straightforward. The LM394 is set at 2mA collector current, which causes the inverting input of IC2 to be at 6.3V. The non-inverting input is therefore biased to be at the same voltage. Feedback is applied to the

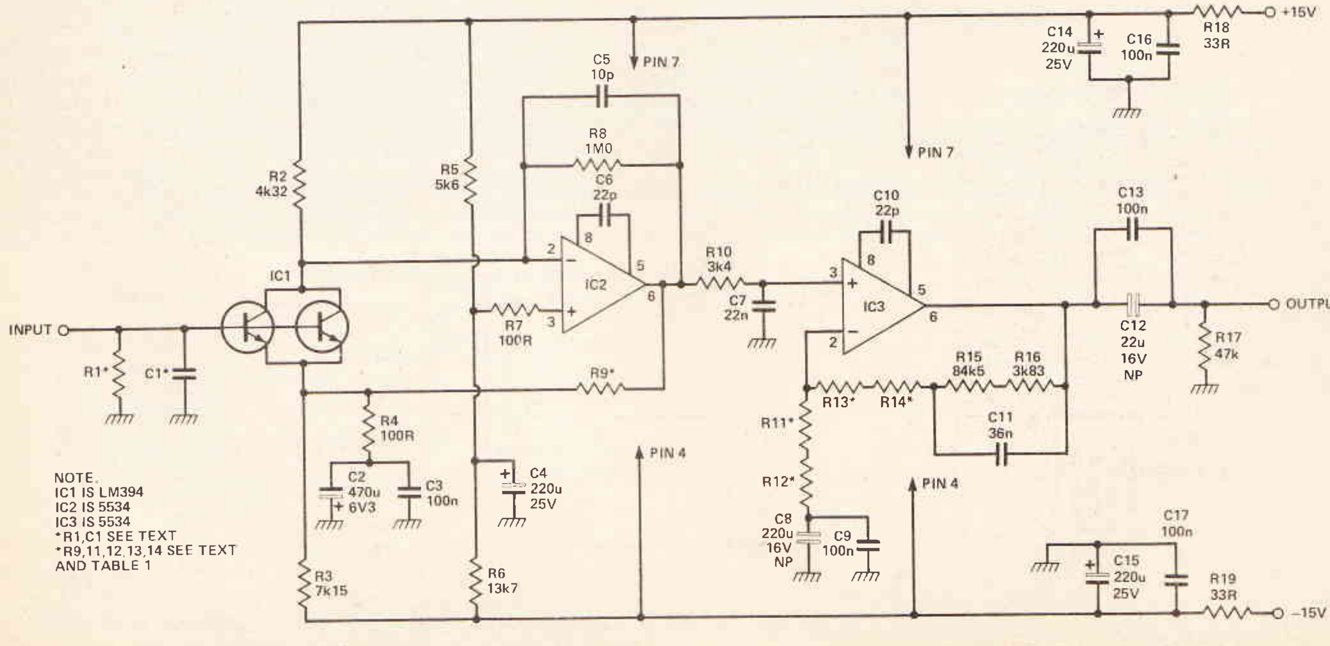


Fig. 2 Circuit diagram of the disc preamplifier stage.

emitter of the LM394 by R9, which, together with the 100 ohm shunt resistor R4, sets the gain of the first stage. This may be calculated from:

$$A(dB) = 20 \log \left(1+\frac{R9}{100}\right)$$

An important consideration at this point is signal overload. This is measured by applying a range of frequencies that have been subjected to inverse RIAA equalisation, and is stated as the amount that the input level can be increased above its nominal rating before the output signal is clipped or severely distorted. As the rated output of the disc amplifier is 200 mV and clipping occurs at about 8.0 V, the overload margin should be:

$$20 \log \left(\frac{8}{0.2}\right) = 32dB$$

at all frequencies. As no equalisation takes place in the first stage, care has to be taken to ensure that high frequency overload does not occur — remember that the 20 kHz input level will be at +19.62 dB — which means that the rated input level multiplied by the first stage gain must not exceed (19.62+32.0) = 51.62 dB below 8.0 V, or about 21.0 mV. A quick calculation based on the gain settings given in Table 1 shows this to be the case, and consequently a full 32.0 dB overload margin will be maintained throughout the audio spectrum.

Following the input stage, a passive network provides the 75μs time constant (3400x22n = 74.8μs) and a network in the feedback circuit of IC3 gives the 3180μs and 318μs breakpoints. The 36n capacitor, C11, with R15+R16 fix the first point (36nx(84.5k+43.83k) = 3179.88μs), and the same capcitor together with the series-parallel combination of R13, 14, 15 and 16 fix the second. Table 2 gives details of the RIAA characteristic over a range of frequencies so that performance of the disc stage may be checked for accuracy, which, with the specified components will typically be to within 0.1 dB between 20 Hz and 20 kHz. Stray capacitance may affect the extreme high frequency response, but the prototype

Input		1st Stage Gain	R9	R11	R12	R13	R14
0.1 mV	Moving coil	41.0 dB	11k0	536R	21R5	8k87	412R
0.2 mV	Moving coil	35.0 dB	5k6	536R	21R5	8k87	412R
0.3 mv	Moving coil	31.48 dB	3k65	536R	21R5	8k87	412R
0.5 mV	Moving coil	27.0 dB	2k15	536R	21R5	8k87	412R
2.0 mV	Moving magnet	20.0 dB	887R	909R	82R5	8k06	806R
3.0 mV	Moving magnet	16.48 dB	562R	909R	82R5	8k06	806R
5.0 mV	Moving magnet	12.0 dB	301R	909R	82R5	8k06	806R
8.0 mV	Moving magnet	7.96 dB	150R	909R	82R5	8k06	806R

Table 1 Component values for the disc amplifier stage.

f(Hz)	dB	f(Hz)	dB	f(Hz)	dB
0	+19.911	100	+13.088	10k	−13.734
5	+19.868	200	+8.219	15k	−17.157
10	+19.743	500	+2.648	20k	−19.620
20k	+19.274	1k	0 (Ref)	30k	−23.117
30	+18.593	2k	−2.589	50k	−27.541
40	+17.792	3k	−4.740	100k	−33.556
50	+16.946	5k	−8.210		

Table 2 RIAA equalisation characteristics of the disc amplifier.

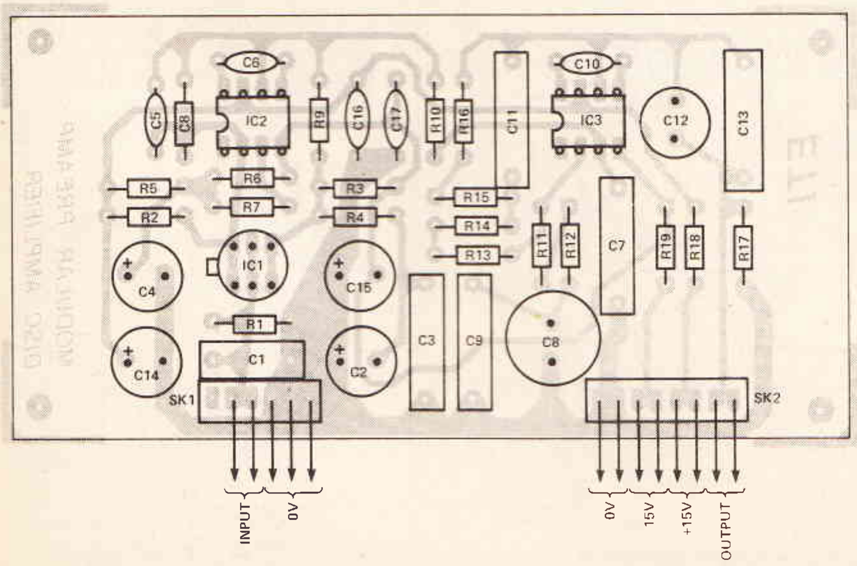


Fig 3 Component overlay of the disc amplifier PCB.

PARTS LIST

Disc Amplifier (one channel only)

Resistors (all 1% metal glaze or metal film)

R1	see text
R2	4k32
R3	7k15
R4, 7	100R
R5	5K6
R6	13k7
R8	1M0
R9	see text
R10	3k4
R11, 12, 13, 14	see text
R15	84k5
R16	3k83
R17	47k
R18, 19	33R

Capacitors

C1	see text
C2	470u 6V3 radial electrolytic
C3,9, 13	100n 250v polycarbonate
C4, 14, 15	220u 25V radial electrolytic
C5	10pf 160V 2½% polystyrene
C6, 10	22pf 160V 2½% polystyrene
C7	22n 63V 1% polystyrene
C8	220u 16V non-polarised electrolytic
C11	36n 63V 1% polystyrene
C12	22u 16V non-polarised electrolytic
C16, 17	100n 100V polyester

Semiconductors

IC1	LM394
IC2, 3	NE5534

Miscellaneous

SK1	6 way PCB socket
SK2	8 way PCB socket
PCB:	

was still accurate to within 0.5 dB at 100 kHz, which should not cause undue concern. There is no particular merit in having equalisation this precise, but as the network design is so simple, there seems no point in not keeping things as tidy as possible. (For anyone interested, the author can provide a T159 programme that calculates the RIAA deviation, at any frequency, to an accuracy of 8 decimal places!)

Unbalanced Output Stage

This stage, which incorporates an active balance control, is placed immediately after the main level control. The same circuit is used, without the balance facility, as a tape recorder output buffer. As shown in Figure 4, it has been designed to allow a limited amount of imbalance between channels — a maximum of 10 dB — with sufficient gain to raise the 200 mV input signals to the 1.0 V rated output of the pre-amplifier. The balance control operates by changing the amount of feedback around the amplifier stage. This method preserves a good signal to noise ratio and overload margin while giving a well controlled image shift. Table 3 shows the amount of imbalance between channels at different positions of the control, and it will be seen that the calibrations are typically accurate to within 0.5dB.

Note that the output capacitor of the stage is within the main feedback loop of the amplifier. This is done for two reasons — it helps to counteract any effects introduced by the capacitor, and it avoids the danger of any DC voltage appearing on the control potentiometer which would introduce noise whenever the control was operated. There have recently been some suggestions that all passive components, such as switches, connectors and potentiometers should be provided with a DC bias voltage, as this helps to provide clean contacts for improved signal transmission. The theory behind this may be well founded, but long experience with recording studio mixing consoles, where it is quite common for DC to appear in all sorts of unwanted places, has shown that the working life of components subjected to this treatment is drastically reduced, so they need replacing much earlier than similar ones that have remained free of DC voltages.

The same stage is also used as a tape recorder buffer, with points A and B linked together and changed values for R4, R6 and C2. R4 should

Control Calibration	Imbalance
2	1.81 dB
4	3.67 dB
6	5.61 dB
8	7.69 dB
10	10.01 db

Table 3 Characteristics of the balance control

Record Output Level	Gain	R6	R4	C2
499.5 mV	7.95 dB	1k50	1k	100u
1.0 V	13.99 dB	4k02	1k	100u
1.2 V (0 VU)	15.72 dB	5k11	1k	100u

Table 4 Component values for the tape output buffer.

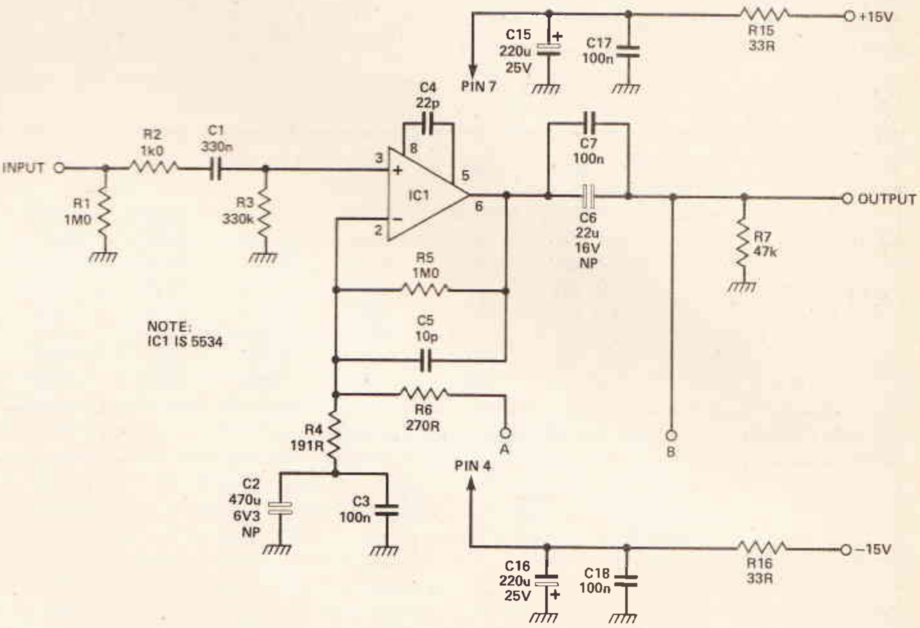


Fig. 4 Circuit diagram of the unbalanced output stage.

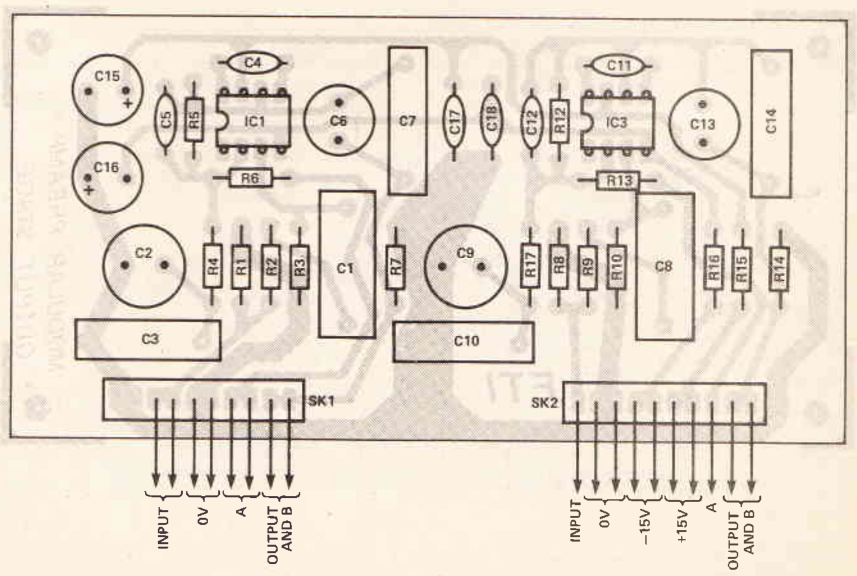


Fig. 5 Component overlay of the unbalanced output stage PCB. Note that this board is for stereo operation and therefore carries two complete output stages.

become 1k ohm, C2 should be changed to 100μ 16V non-polarized and R6 chosen to give the required output level according to Table 4.

The importance of buffering the tape recorder output, as shown in Figure 1, must be stressed. Without the buffer stage, the recorder input would be connected directly to the main signal path of the pre-amplifier. There is nothing wrong with that, provided the recorder is switched on, but some recorder input circuitry can appear very non-linear when it is not powered, and this could introduce high levels of distortion into the pre-amplifier. The buffer stage also presents the opportunity to introduce gain into the record chain, and avoids the danger of a recorder with a low input impedance loading the output of any other piece of equipment that is connected to the pre-amplifier.

The output levels given in Table 4 should be suitable for most applications, but any other gain setting can be used, calculating R6 from:

$$R6 = 1000(G-1).$$

Muting Relay Control

Although not absolutely essential, this simple circuit will more than pay for itself the first time you switch your equipment on in the wrong sequence and it saves your speakers, eardrums or central nervous system from instant destruction. The circuit (Fig. 7) controls a relay which, in its relaxed state, shorts the main signal outputs to earth via R4 and R5. This means that the signal does not normally pass through the relay contacts, and is therefore unaffected by their presence. When power is applied to the pre-amplifier, the relay remains relaxed until the voltage on the base of Q1 has risen to 0.6V when Q1 and Q2 turn on, opening the relay contacts that are shorting the signal to earth. The 560 ohm resistors are in series with the output signal to prevent the output amplifier stages from being overstressed by the short circuit condition. Note that power to the relay is supplied from both rails, so that if one rail is not present, the output will remain muted. This eliminates a situation where, if the negative rail has failed, a 5534 will sometimes oscillate at a frequency approaching that of Heathrow Air Traffic Control, causing havoc to tweeter voice coils, bats and Boeing 747s.

The 6.8 V zener diode ZD1 will normally be connected to earth at a convenient point but, if headphone amplifiers are to be fitted, it may be earthed via the break contacts on the phones jack socket. Insertion of a jack plug will then de-energise the relay so that the main outputs are muted, and also apply power to the headphone amplifiers so that the programme is played only through the headphones. The relay is also used to provide remote switching for use with active speakers and other ancillaries.

Power Supply

This is based on IC Regulator types 7815 and 7915 (Fig. 8). Ideally, these should be mounted within the pre-amplifier with the transformer and main smoothing capacitors separately housed and placed some distance away to minimize the danger of hum pick-up. If the complete supply is contained within the pre-amplifier case, it is essential that a toroidal mains transformer is used, as the problems of screening will be considerably reduced.

Although the power supply appears simple, one or two tips may be in order. The 0.1μf capacitors, C4,5,8 and 9, should be mounted as close to the regulators as possible, and care should be taken to establish a single earth path from the transformer centre tap to the OV output. Contact suppressors should be connected across the mains switch as shown. The power 'On'

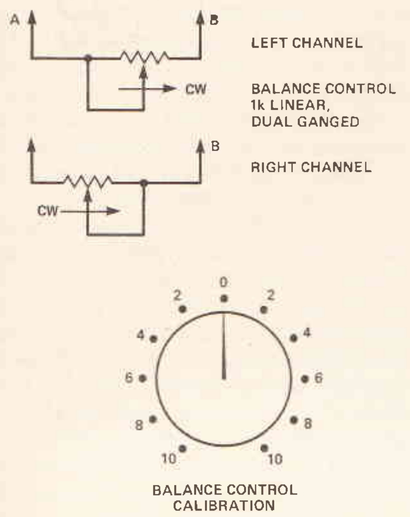


Fig. 6 Balance control connections and calibration.

PARTS LIST

Unbalanced Output Stage

Resistors (all 1% metal glaze or metal film)	
R1, 5, 8, 12	1M0
R2, 9	1k0
R3, 10	330k
R4, 11	191R
R6, 13	270R
R7, 14	47k
R15, 16	33R
Capacitors	
C1, 8	330n 250V polycarbonate
C2, 9	470u 6V3 non-polarised electrolytic
C3, 7, 10, 14	100n 250V polycarbonate
C4, 11	22pf 160V 2½% polystyrene
C5, 12	10pf 160V 2½% polystyrene
C6, 13	22u 16V non-polarised electrolytic
C15, 16	220u 25V radial electrolytic
C17, 18	100n 100V polyester
Semiconductors	
IC1, 2	NE5534
Miscellaneous	
SK1, 2	10 way PCB sockets
PCB:	

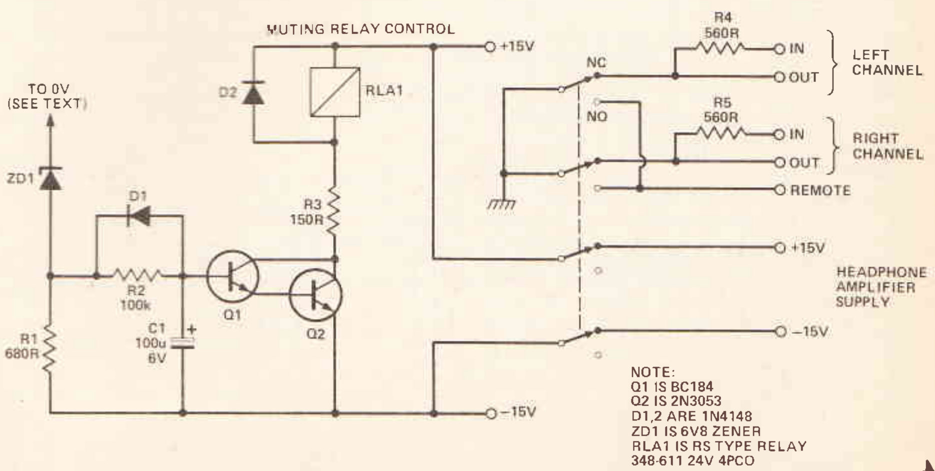


Fig. 7 Circuit diagram of the muting relay control.

LED is connected between both stabilized rails so that it acts as an indicator that all is well in the power supply department. The regulators do not require heatsinks when only the basic unit is constructed, but if headphone amplifiers are included, IC1 and IC2 should be mounted on standard T0220 finned heatsinks, or attached to the metal chassis using the insulating washers supplied with the devices.

Construction

The individual 'building block' circuit boards should be fitted with interconnecting sockets which mate with matching plugs on the mother board. The contacts of the recommended connectors are on a 0.1" pitch so that if necessary, Vero board can be used for the mother board, and indeed, for the plug-in boards as well if you do not want to go to the expense of obtaining proper printed circuit boards.

Suitable cabinets are available from such suppliers as West Hyde Developments and Maplin, who can also provide the front panel controls There are no special requirements for these except that they are of a reasonable audio grade. The input selector switch, which needs to be a 2 pole 4 position type, should be purchased as a 4 pole variety so that each contact can be doubled up for reliability. It is not necessary that the switch contacts are gold plated, providing they have a good, firm wiping action, so any build-up of deposits is removed with each operation. The potentiometers should be good quality carbon or cermet types with multi-contact wipers. If they can be obtained, the special audio controls from the larger Japanese suppliers, such as Alps, are of very high quality, and are not expensive. It has already been suggested that the best value for the level potentiometer is 10k ohms, although if this is likely to cause loading problems, 25k is acceptable. It is worth remembering that the Japanese D law is preferable to the usual logarithmic law, as it gives a much smoother control of the output. To avoid the image shifting with different settings of the level control, the two sections should be matched to within 1dB over most of their travel. The balance control should not suffer from this shortcoming, as linear potentiomenters are normally made to tighter tolerances, but as a general rule, the better quality the component, the greater is the chance of accuracy.

If lever or toggle switches are used for the tape monitor and direct functions, these should have contacts that are suitable for low level audio use, and again, suppliers such as Alps seem to have got the problem licked. Phone sockets used for signal connections should preferably be gold plated, and must be isolated from the chassis. This can prove difficult if the rear panel is thicker than about 1.0 mm, as most available sockets do not have sufficient length of threaded bush to pass through a thick panel as well as the insulating

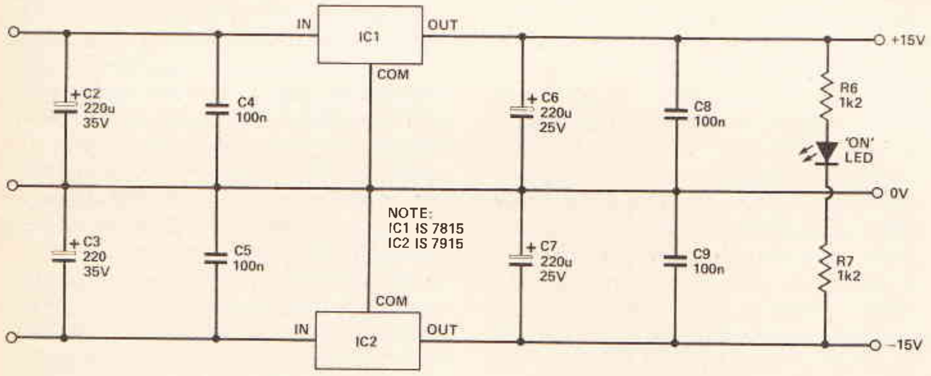


Fig 8. Circuit diagram of the power supply.

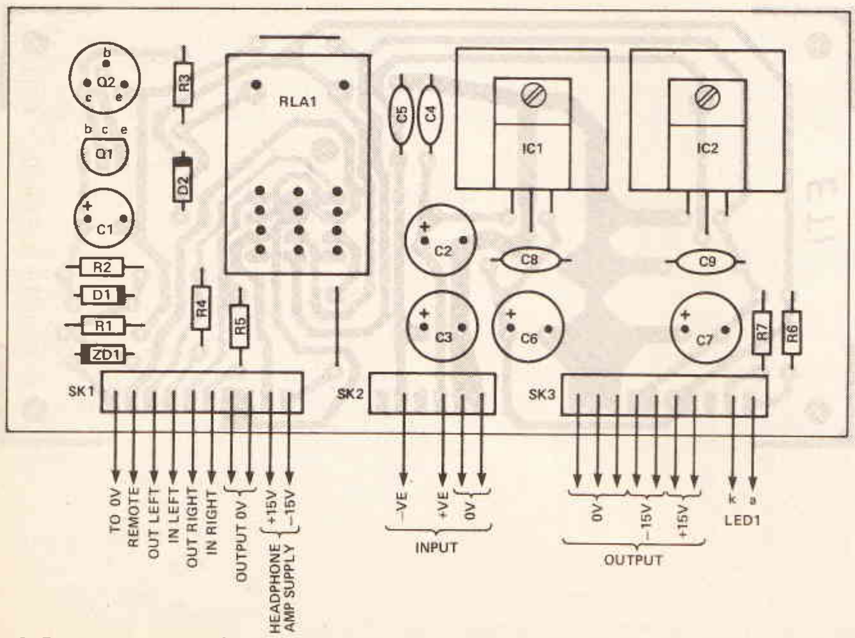


Fig. 9 Component overlay of the power supply and muting relay control PCB.

PARTS LIST

Power Supply and Muting Circuit

Resistors	
R1	680R 5%
R2	100k 5%
R3	390R 1W 5%
R4, 5	560R 1% metal glaze or metal film
R6, 7	1k2 5%
Capacitors	
C1	100u 25v radial electrolytic
C2, 3	220u 35V radial electrolytic
C4, 5, 8, 9	100n 100V polyester
C6, 7	220u 25V radial electrolytic
Semiconductors	
IC1	7815
IC2	7815
Q1	BC184
Q2	2N3053
D1, 2	1N4148
ZD1	6V8 400 mW zener
Miscellaneous	
SK1,3	10 way PCB sockets
SK2	6 way PCB sockets

PCB: heatsinks and nuts, bolts, etc to suite (see text); 12V 185R 4 pole changeover realy, continental series.

washers. One solution is to mount the connectors onto a piece of fibreglass circuit board material and drill clearance holes in the panel.

The internal construction is quite straightforward. Vertical guides should be mounted on the mother board to locate and support the individual circuit board, and care should be taken to ensure that the signal earth is not connected to the chassis at any point — for example, chassis mounted power supply capacitors should be checked to make certain that their cans are not earthed by their mounting clips.

Individual screened wires should be used to connect the rear panel sockets to the mother board, with twisted lenghts of 16/02 stranded wire carrying the DC supplies. If a separate power supply unit is used, a 7 pin DIN socket should be employed to connect this to the preamplifier, but be sure to use the heavy, cast type, as the common lightweight ones can easily be plugged together upside-down, with obvious consequences.

A major problem with home constructed equipment is usually caused by the earthing techniques employed. There is no secret path to success — just use the same method that manufacturers use — its called trial and error! There are one or two rules to follow, such as making the earth follow the signal and separating the signal output and power supply earths, but once the unit is working, the best earthing arrangement is usually found by ear. Figure 11 shows, in very simplified form, an earthing arrangement that was successful in the prototype. The most difficult job was to prevent the unit from being extremely sensitive to external hum fields, such as those generated by the mains transformer in a typical power amplifier. Eventually a cure was found by breaking the rule that the signal earth connects to the chassis at the input of the most sensitive circuit. For instance, the most satisfactory arrangement was to connect the earth at the output of the disc amplifier stage to chassis. This eliminated all traces of hum pick-up, but turned the preamplifier into a very good radio receiver. This was cured by connecting a 1000pf ceramic capacitor between the shell of the disc input sockets and the chassis (and in doing so, losing a very interesting CB conversation between Naughty Nora and The Cannonball!).

Once construction is complete, power should be applied to the mother board without the individual boards present. Providing all is well, the power supply regulator board should be plugged in and the busses checked to ensure that the 15-0-15 V supplies are operating correctly, which means that each rail should measure between 14.5 and 15.5V with respect to earth. The muting circuit should next be tested — correct operation being indicated by the relay operating about 5 seconds after power is applied.

The remaining circuit boards may now be plugged in and the complete signal path checked. If the unit appears to be working correctly, leave it switched on for ten to fifteen minutes, then place a finger tip on each IC in turn. None should be more than warm to the touch, including the supply regulators. If any device is hot, this is a sign that excess current is being drawn, so start a systematic search for a wrong component or assembly fault. If any of the 5534 ICs are not working, check the DC voltages on the connecting pins. Pin 7 should be at +15 V and Pin 4 at −15 V. If these are correct, Pins 2, 3 and 6 should all be approximately at 0 V, and if this is not the case, the IC may be suspect. The easiest way to proceed is to change the device for a new one, but if this does not bring about a cure, the fault is likely to be with one of the associated passive components — for example, the small value polystyrene capacitors can be prone to shorting if too much heat is applied during soldering. Should the one between Pins 5 and 8 of a 5534 become shorted, the IC will not work, and will give every indiction that it is faulty.

Once all is working, the unit should be connected to a power amplifier and speakers and the system checked for excess hum. The chances are that there will be plenty of this in evidence, so the trial and error procedure must be adopted until it is elminated. Try earthing different parts of the pre-amplifer signal earth path to the chassis with a short length of thick wire. Once the position that gives minimum hum has been found, short out the disc input sockets and check that the hum output has not increased. If it has, continue with the trial and error

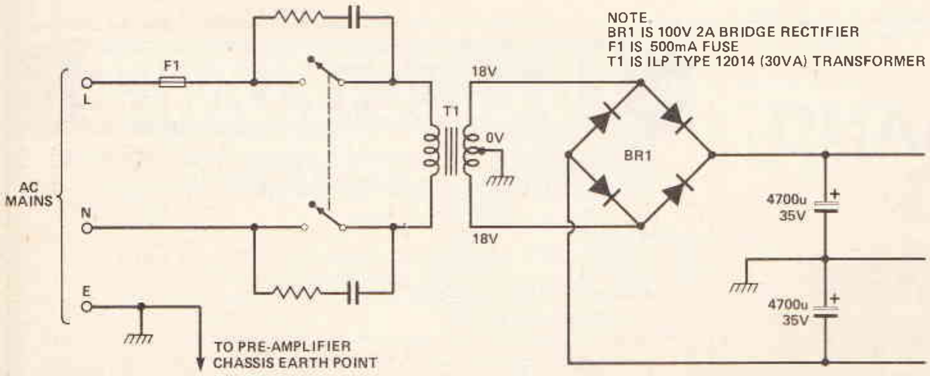


Fig. 10 Suggested circuit to feed the regulated power supply.

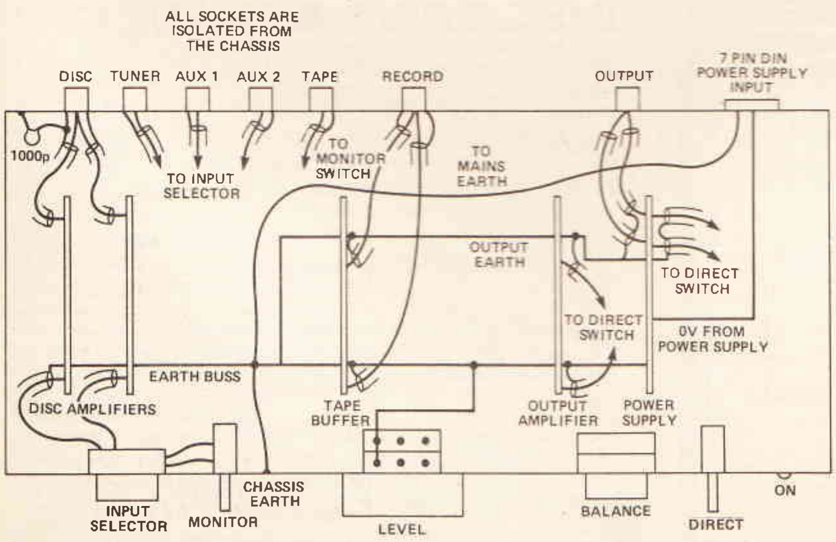


Fig. 11 A possible earthing arrangement.

exercise until optimum earthing has been achieved, then install permanent wiring where necessary.

Once it's working, what can you expect? It is nice to report that the performance of the prototype was well up to expectation. Distortion was virtually unmeasurable, being equal to the test equipment residual on the auxiliary inputs (0.0018%), and well down into the noise on the moving coil inputs. Signal to noise of the moving coil stage was better than −75dB (A weighted, 0.5 mV input, 0.5 V output). The RIAA equalisation curve was within 0.15 dB between 20 Hz and 20 kHz, and crosstalk was better than −65 dB at 20 kHz and −83 dB at 1 kHz.

Subjectively, the unit sounds clean and analytical. Hum and noise never intrude and dynamics are handled with an ease that leads the listener to believe that it will never overload; in fact it is all that a good pre-amplifier should be, in that it is the quality of the source material that decides the quality of sound coming from the speakers.

BUYLINES

The PCB plugs and sockets are available from both Maplin and Ambit, although neither carries a full range so you might have to buy from both. The relay is available from Watford Electronics. Note that no provision has been made for the use of a relay socket, so if you prefer to use one you will have to adjust the pads on the PCB. You could, of course, use any other four pole relay with a coil operating voltage of 30V or less by adjusting the layout and the value of R3. Several different types of heatsink would be suitable or if you prefer, you could make your own quite simply. Some of the 1% tolerance resistances are in the E24 range which is widely available but others are in the E96 range which is not. If all else fails, most of the values can be produced by placing two E24 values in series, and doing so will neither compromise the tolerance figure nor introduce extra noise. Maplin and Electrovalue supply non-polarised electrolytics but in axial, not radial, form, and again you might have to do a little juggling to get the right values. We are hoping to make a complete kit of parts for this project available, but were unable to make the arrangements in time for details to appear in this issue. Meanwhile, if any one out there can supply the 1% resistors and non-polarised capacitors, let us know and we'll give you a mention.

Note that the PCBs for this project will NOT be available through our PCB service.

The second part of this article in next month's ETI will contain details of the mother board and the three remaining modules.

ETI

TECH TIPS

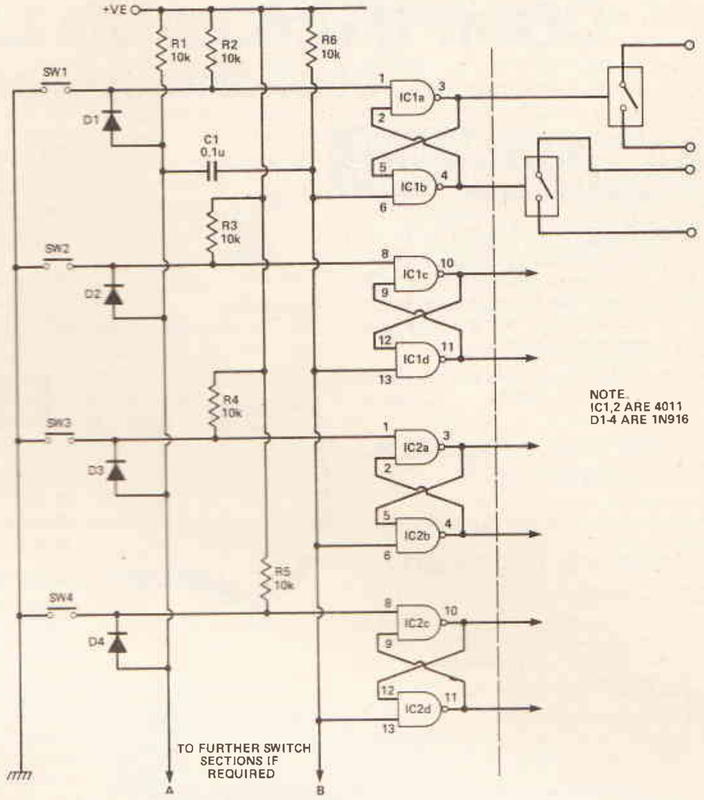
Latching Switches

Clive Pantrey, Farnborough.

This circuit allows individual, momentary-action, push to make switches to be used in a ganged, latching mode for logic or low level audio signals.

When a switch is pressed the common reset line of all the latches sees a momentary ground, through C1 and its associated diode, this resets the previous selection and allows the selected output to latch.

A number of different devices could be connected to the latch outputs to provide various types of switches, bi-lateral switches are shown on the circuit. Further stages can be added to the bank as required, by connecting to points A and B.



Linear to Log Convertor

D. R. Fowness Wolverhampton

This logarithmic generator utilises the inherent antilogarithmic transconductance of the transistor function, and works around a feedback circuit that balances the input current.

The input amplifier, IC1, ensures that the collector current of Q1 is equal to the input current. The reference current will be equal to the collector current of Q2. Transistors Q1 and Q2 should be a matched pair, and be mounted in thermal contact.

The voltage at the non-inverting input of IC2 will be:

$$V_{beQ2} - V_{beQ1}$$

but

$$V_{beQ1} = \frac{kT}{q} \times \log\left(\frac{I_c}{I_o}\right)$$

and

$$V_{beQ2} = \frac{kT}{q} \times \log\left(\frac{I_r}{I_o}\right)$$

so that the voltage at IC2 non-inverting input will be:

$$\frac{kT}{q} \log\left(\frac{I_r}{I_c}\right)$$

where

I_c = input current

I_r = reference current

I_o = reverse saturation current

T = temperature

k = Boltzman's constant

q = charge on an electron

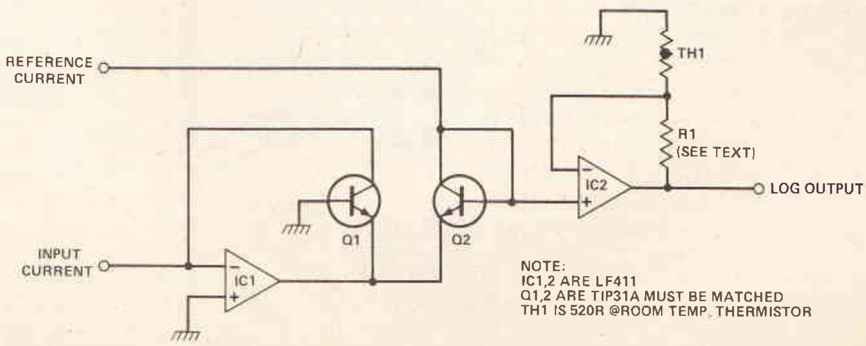
At room temperature, kT/q is approximately 0.26 mV.

The scaling factor of amplifier IC2 (ie the gain) is given by (R1+R2)/R1. The scaling factor is equal to the number of output volts corresponding to one decade change of the ratio. R1 is the thermistor which should be chosen to compensate for any change in temperature and so maintain a constant gain.

The output voltage will be given by

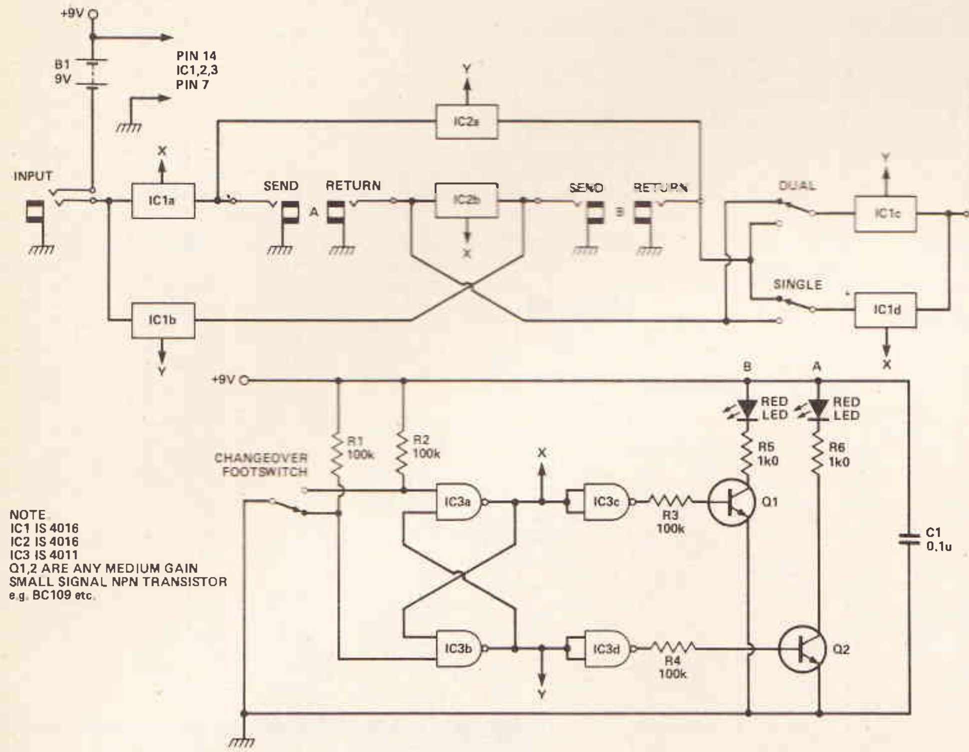
$$\frac{(R1+R2)}{R1} \times 0.26 \log\left(\frac{I_c}{I_r}\right)$$

Note that all the logarithms are in base e, and not base 10!



De-Luxe AB Box

Marcus Valentine,
Stafford.



This Audio line signal routing device was designed for one of those guitarists who feel insecure unless they are surrounded by numerous effects boxes, but who wish to have more control over them collectively. It has two modes: single and dual.

In the single mode, depression of the footswitch noislessly reroutes the signal path from going through chain A, to chain B, a chain being either a straight jack to jack lead, an effect, or a series of effects.

In the dual mode, the signal is rerouted through chain A followed by chain B, and on depression of the footswitch (here's the clever bit) is re-routed to chain B followed by chain A.

The two LEDs indicate the chain selected in the single mode, and in the dual mode the first chain.

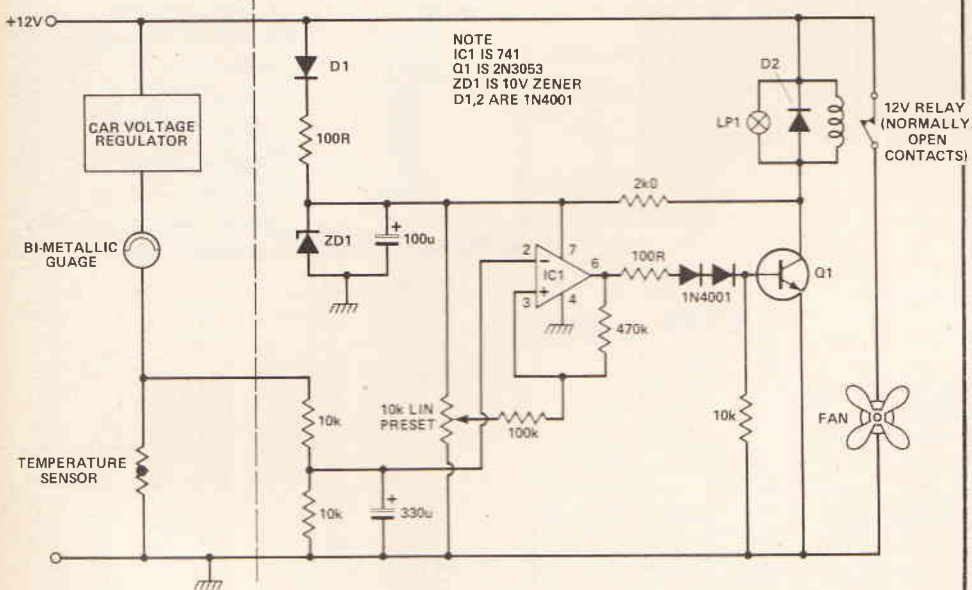
The flip-flop built around N1 and N2 ensures that the bilateral switches used change state cleanly and quickly, and more importantly, at the same time.

Current consumption, which is set mainly by the LEDs, is low enough to allow a PP3 to be used as power. The LEDs were considered essential for ease of use.

The device can be conveniently constructed in an aluminium box measuring 10x10x4 cm, with the input socket arranged so that the input plug connects the negative supply.

By using various combinations of sockets, the device can be utilised in many more audio signal rerouting applications, eg, by using the A and B return stockets and output only, (with a dummy plug inserted into the input socket to provide power) the box can be used as a single selector.

Car Fan Control



J. N. Swanson,
Sheffield.

If, like me, you own an old car with a conventional fan, driven from the engine, a worthwhile improvement can be obtained by fitting an electric fan in its place. These can readily be bought for about £5 from a scrap yard. The advantages gained are better fuel consumption and lower engine noise particularly at high revs.

A problem arises in finding a suitable switch to operate the fan at the required temperature. Most of the switches fitted to the cars are fitted in a threaded hole in the side of the radiator which means that most scrap yards are unwilling to separate the two. For this reason I have designed a circuit to switch on the fan using the existing temperature sensor for the temperature guage.

The voltage regulator on the car usually works by interupting the supply so as to provide an average level of about 10V. Because of this, a fair bit of smoothing is required in order to stop the fan switching on and off with the regulator. A zenner diode provides a 10V supply for the op-amp and the reference voltage. The 470k and 100k resistors provide a certain amount of hysteresis and the two diodes prevent the transistor turning on due to offset of the op-amp. The fan may run for a few seconds when the ignition is initially turned on. This may be prevented by increasing the 100uF capacitor to a few thousand uF, but I find this useful as otherwise in winter the fan may not run for weeks on end.

RESISTORS

CARBON FILM 5%
HI STAB 10Ω TO 10M
¼W E24 2p
½W E24 2½p
1W E24 6p
2W E24 12p

METAL FILM E24 ULTRA HI STAB ULTRA LOW NOISE 0.4W 10Ω TO 1M
2% E24 5p
1% E24 6p

LOW OHMIC GLAZE E12
0.22Ω to 8.2Ω 11p

WIRE-WOUND E12
2 to 3W 0.22Ω to 330Ω 28p
4 to 7W 0.47Ω to 6K8 33p
10 to 11W 1Ω to 33K 37p

POTS & PRESETS

LOW NOISE E3 ROTARY POTS WITH ¼" SPINDLES 4K7 TO 2M
LIN 40p
LOG 40p
As above with DP Mains Switch 90p
As above stereo (no switch) 1.00

DUSTPROOF PRESETS E3 100Ω TO 10M
Mini Vert. 15p
Mini Horiz. 15p
Standard Vert 18p
Standard Horiz 18p
Thumbwheel or ¼" Spindle for Standard Types only 8p

¾" CERMET 20 TURN PRESETS
50Ω, 100Ω, 200Ω, 500Ω, 1K, 2K, 5K, 10K, 20K, 50K, 100K, 200K, 500K each 89p

THERMISTORS & VDRs PLEASE PHONE

CAPS

CERAMIC DISC/PLATE MICRO—MINI 100V TYPICALLY 5% E12
1pF to 10nF 7p

SIEMENS 63V MONOLYTHIC MINI CERAMIC
10nF, 22nF 10p
33nF, 47nF 10p
68nF 14p
100nF 14p

BARRIER LAYER CERAMIC DISC
220nF, 25V 15p

POLYSTYRENE 160V 5% OR BETTER
10pF, 15pF, 22pF, 27pF, 33pF, 39pF, 47pF, 68pF, 100pF, 150pF, 180pF, 220pF, 270pF, 330pF, 390pF 10p
470pF, 680pF, 1nF, 1.5nF 12p
2.2nF, 3.3nF 13p
4.7nF 14p
10nF 15p

SILVERED MICA 1% PLEASE PHONE

POLYESTER C280 TYPE (RADIAL) 250V
10nF, 15nF, 22nF, 33nF, 47nF, 68nF, 100nF 7p
150nF, 200nF 10p
330nF, 470nF 13p
680nF 18p
1µF 22p
1.5µF 39p
2.2µF 39p

SIEMENS POLY-C 5% 250V 7.5MM
1nF, 1n5, 2n2, 3n3, 4n7, 6n8 7p
8n2, 10n, 12n, 15n, 18n, 22n, 27n, 33n, 39n, 47n 8p
56n, 68n, 82n, 100n, 150n 10p

SIEMENS POLY-C 5% 100V 7.5MM
100n, 120n, 150n 11p
180n, 220n, 270n 14p
330n, 390n 20p
470n, 560n 26p
680n 30p
1µF (10mm) 35p

400V POLYESTER
1n, 1n5, 2n2, 3n3, 4n7m 6n8 7p
10n 10p
15n, 22n, 33n 11p
47n, 68n, 100n 14p
150n, 220n 18p
330n 39p
470n 50p

630VDC 250VAC IDEAL AS MAINS SUPPRESSORS
10nF 28p
15nF 22nF 35p
47nF 39p
100nF 43p
150nF 49p
220nF 55p

1000VDC PLASTIC
1nF, 2n2 26p
4n7, 6n8 29p
10nF 31p
22nF, 33nF 37p
47nF 41p
100nF 45p
220nF 79p
470nF 1.25

HI VOLT CERMIC
100pF 1KV 25p
100pF 2KV 30p
100pF 3KV 33p
100pF 4KV 37p
220pF 6KV 45p
470pF 2KV 39p
470pF 6KV 49p
1nF 2KV 39p
1nF 6KV 44p
2n2 2KV 44p
2n2 6KV 49p
3n3 2KV 47p
3n3 4KV 52p
4n7 4KV 57p
10nF 2KV 57p

FEEDTHRO' CAP
1nF 500V 7p

TRIMMERS MINI FILM(MULLARD) UP TO 100VDC
1p4 to 5pF (800MHz) 23p
2pF to 10pF (600MHz) 27p
2pF to 22pF (400MHz) 29p
5p5 to 65pF (200MHz) 36p

ELECTROLYTICS Axial by Siemens or Matsushita (Nat. Panasonic)

µFd	V	
.47	63	8p
.47	100	9p
.47	350	30p
1	63	8p
1	100	9p
1	500	40p
2.2	25	8p
2.2	63	9p
2.2	100	11p
2.2	350	30p
3.3	25	10p
3.3	40	11p
3.3	63	12p
4.7	16	8p
4.7	25	9p
4.7	40	9p
4.7	63	12p
4.7	100	14p
10	25	8p
10	40	12p
10	63	14p
10	100	16p
10	350	55p
22	25	11p
22	40	14p
22	63	16p
22	100	21p
47	25	14p
47	40	17p
47	63	28p
47	100	28p
100	16	14p
100	25	16p
100	40	22p
100	63	25p
100	100	30p
220	10	16p
220	16	17p
220	25	22p
220	40	25p
220	63	30p
220	100	40p
470	16	22p
470	25	28p
470	40	36p
470	63	43p
470	100	60p
1000	16	30p
1000	25	38p
1000	40	46p
1000	63	65p
2000	16	48p
2200	25	63p
2200	40	70p
2200	63	134p
4700	16	75p
4700	25	89p

Radial by Matsushita

µFd	V	
10	16	6p
22	10	6p
22	16	7p
47	10	7p
47	16	8p
100	10	9p
100	16	10p
220	10	11p
220	16	12p
470	10	17p
470	16	18p
1000	10	20p
1000	16	24p
2200	10	34p
2200	16	44p
3300	10	50p
3300	16	65p
4700	10	65p
4700	16	95p

CAN ELECTROLYTICS
4700µF 40V 2.50
4700µF 63V 3.50
10,000µF 80V 4.95

TANTALUM BEADS
0.1/35V 14p
22/35V 14p
33/35V 14p
47/35V 14p
68/35V 14p
1.0/35V 14p
2.2/16V 14p
2.2/35V 14p
3.3/35V 18p
4.7/16V 18p
4.7/35V 20p
6.8/25 20p
6.8/35V 21p
10/16V 18p
10/35V 27p
15/16V 22p
15/25V 32p
22/6.3V 26p
22/16V 29p
33/10V 29p
47/6.3V 30p

100/3V 32p

MANY MORE CAPACITORS IN STOCK: PLS PHONE

TRANS-FORMERS

100mA
6-0-6V, 9-0-9V, 12-0-12V, 15-0-15 95p

6VA
0-6, 0-6V 2.95
0-12, 0-12V 2.95
0-15, 0-15V 2.95
0-20, 0-20V 2.95

30VA
6, 6, 9, 9V (total 30V 1A) 4.95

50VA
0-12, 0-12V 5.25

100VA
0-12, 0-12V 9.50

TOROIDALS
Up to 500VA in stock. Please Phone

Please add adequate P&P as transformers are heavy!

WIRE & CABLE

PRICES PER METRE
Solid Hook-up Any Colour 5p

MAINS/ SPEAKER
Twin 1 Amp 14p
Twin 2½ Amp 16p
3 Core 2½ Amp 18p
3 Core 6 Amp 31p
3 Core 13 Amp 56p

SCREENED
Single 14p
Stereo 27p
Mini Single 12p
Mini Stereo 15p
4 Core 4 Screens 44p
4 Core Single Screen 54p
6 Core 61p
12 Core 80p
Heavy Duty Mike/Guitar Lead 25p

AERIAL
50Ω RG58A 25p
75Ω UHF 29p
75Ω VHF 28p
300Ω Flat 14p

RAINBOW RIBBON
Prices per foot
8 way 25p
10 way 25p
16 way 39p
20 way 48p
24 way 62p
30 way 75p
32 way 82p
40 way 88p

PCB MAT

GRADE ONE GLASS PCB SINGLE-SIDED
178 × 240mm 150p
420 × 195mm 1.95
420 × 245mm 2.95

FERRIC CHLORIDE PELLETS
Quick dissolving. Enough to make over 1 litre 1.69

DALO ETCH RESIST PEN (inc Spare Nib) 1.20

ETCH RESIST TRANSFERS
1. Thin lines
2. Thick lines
3. Thin bends
4. Thick bends
5. DIL pads
6. Transistor pads
7. Dots + holes
8. 0.1" edge connectors
9. Mixture
Any sheet of above 35p

PHOTO SENSITIVE PCB
1st Class Epoxy Glass. For better results than spraying. Expose to UV
Single sided
100 × 160 2.10
100 × 220 2.50
203 × 114 2.40
233 × 220 5.20
Double Sided
100 × 160 2.20
100 × 200 2.80
203 × 114 2.90
233 × 220 5.90
Developer for above (do not use Sodium Hydroxide) 500 ml 2.95

VERO

0.1" COPPER CLAD
2.5 × 3.7 83p
2.5 × 5 99p
3.75 × 3.75 99p
3.75 × 5 1.14
2.5 × 17 2.99
3.75 × 17 3.85
4.75 × 17 4.93
VQ Board 1.92
Dip Board 3.90
Track Cutter 1.48
Pin Insertor 1.79
100Pins 55p
Verobloc 3.99

Vero Wiring
Pen + Spool 3.35
Spare Spool 75p
Combs 6p

SWITCHES

DIL SPST
4 way 67p
6 way 82p
8 way 90p
10 way 1.40

TOGGLE (MINI)
SPST 49p
SPDT 59p
DPDT 69p
DPDT C.OFF 79p
4PDT 2.75
All toggles in biased toggles in stock. Please phone

PUSH BUTTON
Non Latching Push to Make 18p
Push to Break 28p

KEY SWITCH
Mains 4 amps DPST withdraw Key in both postions (inc 2 keys) 3.95

FOOTSWITCH with metal buttons
SPDT 1.85
DPDT 2.75

ROTARY
Main DP 4 amps with ¼" spindle 65p
Lorlin Adjustable Stop Type 1p 1 to 12 way 55p
2p 2 to 6 way 55p
3p 3 to 4 way 55p
4p 4 to 3 way 55p
Many other switches in stock. Please Phone

CONN-ECTORS PLUGS & SOCKETS

DIL SOCKETS

Pins	Lo-prof	WWp
8	8p	25p
14	9p	35p
16	10p	40p
18	16p	50p
20	20p	—
22	22p	—
24	24p	70p
28	28p	79p
40	30p	99p

ZERO INSERTION FORCE DIL SOCKETS
24 pin 4.25
40 pin 5.25

UHF PL269 TYPES
Low loss, superior quality 50Ω
Line plus 45p
Reducer 15p
Round skt 40p
Sqr skt 40p

BNC 50Ω
Plug 1.10
Socket 1.00
Line skt 1.15

COAX (TV) *All Metal*
Plug 25p
Socket 25p
Line Skt 40p

CANNON TYPE AUDIO PLUGS (3 PIN XLR)
Male 1.70
Female 1.65
Sockets (Chassis)
Male 1.50
Female 2.35

JACK PLUGS Huge Discount for quantity Please phone
¼" Mono 20p
¼" Stereo 20p
¼" Metal Mono 30p
2½" mm Mono 12p
2½ mm Metal Mono 20p
3½ mm Mono 12p
3½ MM Stereo 35p
3½ MM Metal Mono 20p

JACK SOCKETS Chassis
¼" Mono 20p
¼" Stereo 25p
2½ mm Mono 10p
3½ mm Mono 15p
Line
¼" Mono 20p
¼" Metal 40p
¼" Stereo 30p
¼" Stereo Metal 50p
3½ mm Mono 15p
3½ mm Mono Line 20p

D CONNECTORS Solder Type Male
9 way 80p
15 way 1.03
25 way 1.60
37 way 2.50
Female
9 way 99p
15 way 1.75
25 way 2.05
37 way 3.30
Angled PCB
25w Male 2.45
25w Female 2.90
Covers 99p

EURO CONNECTORS Male
31 way 1.75
64w A + B Straight 2.25
64w A + B Angled 2.95
64w A + C Straight 2.40
64w A + C Angled 2.95
Female
31 way 1.75
64w A + B Straight 2.25
64w A + B Angled 2.95
64w A + C Straight 2.95
64w A + C Angled 3.35

IDC CONNECTORS PCB Male—Latch Straight
10 way 89p
16 way 1.29
20 way 1.45
26 way 1.75
34 way 1.99
40 way 2.25
50 way 2.45
PCB Male—Latch Angled
10 way 95p
16 way 1.47
20 way 1.60
26 way 1.99
34 way 2.40
40 way 2.55
50 way 2.75
Female Header
10 way 84p
16 way 1.07
20 way 1.25
26 way 1.49
34 way 1.82
40 way 1.85
50 way 1.99

DIN PLUGS
2 pin 9p
3 pin 11p
5 pin 180° 12p
5 pin 240° 16p
5 pin Domino 50p
6 pin 18p
7 pin 30p

DIN CHASSIS SOCKETS
2 pin 9p
3 pin 10p
5 pin 180° 10p
5 pin 240° 16p
6 pin 20p
7 pin 25p

DIN LINE SOCKETS
2 pin 10p
3 pin use 5p 180°
5 pin 15p

PHONO PLUGS
Metal 20p
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All fit ¼" spindles Black (suffix B) Grey (suffix G)
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S150G plain 56p
S151B + line 64p
S151G + line 64p
15mm Standard
K150B plain 57p
K150G plain 57p
K151B + line 66p
K151G + line 66p
15mm Winged
W150B 74p
W150G 74p
21mm Short
S210B plain 69p
S210G plain 69p
S211B + line 75p
S211G + line 75p
21mm Standard
K210B plain 69p
K210G plain 69p
K211B + line 78p
K211G + line 78p
21mm Winged
W210B 86p
W210G 86p
29mm Standard
K290B 88p
K290G 88p

CAPS: Blk, Red, Yel, Grn, Grey, Blue (Please state colour)
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15mm + dot 8p
15mm + line 8p
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	Slow	Fast
100mA	19p	15p
250mA	17p	10p
315mA	17p	10p
500mA	17p	10p
630mA	17p	10p
800mA	17p	10p
1A	17p	10p
1.6A	17p	10p
2A	17p	10p
3.15A	17p	10p
4A	17p	10p
5A	17p	10p
6.3A	17p	10p
10A	17p	10p

1¼" Slow Fast

	Slow	Fast
100mA	19p	15p
250mA	17p	10p
315mA	17p	10p
500mA	17p	10p
600mA	17p	10p
800mA	17p	10p
1A	17p	10p
1.5A	17p	10p
2A	17p	10p
3A	17p	10p
4A	—	10p
5A	—	10p
6A	—	10p
10A	—	10p
15A	—	10p
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		2N4266	45p	2SC1096	1.55	BC169B	10p	BC414	25p	BF185	37p
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		2N4302	39p	3N139	4.29	BC172B	15p	BC546B	15p	BF244A	35p
		2N4303	40p	3N140	3.30	BC172C	16p	BC547	13p	BF244B	39p
		2N4304	41p	3N143	1.07	BC173	11p	BC547A	14p	BF245A	30p
				3N152	2.85	BC173B	16p	BC547B	14p	BF245B	51p
				3N153	3.00	BC173C	16p	BC548	12p	BF246	52p
				3N154	2.47	BC174	21p			BF246A	39p
					2.56						

LIGHTSAVER

Here's a nifty little circuit that should be of universal applicability, wherever there are lightbulbs that get switched on and off a fair amount. Circuit by Kevin Jones.

Incandescent lamps almost invariably 'blow' when they are first switched on. The reason for this is that the cold resistance of the filament is very much lower than the hot resistance, with the result that a very large current can flow at switch on while the filament is heating up.

Filaments are, obviously, designed to withstand this surge, otherwise incandescent lights would not exist. However, part of the art of the manufacturer is not to 'over-engineer' a project (or, to the cynical, not to make products that last too long). This means that the average domestic light bulb can stand this sort of treatment for only so long before sucumbing.

There is a way of reducing the stress on the filament, however, and this is by implementing zero-crossing switching. In this, the initial current into the filament is allowed to flow only when the instantaneous voltage of the AC mains is well away from the peak voltage. In the circuit given here, the maximum voltage at turn-on will be 80 volts.

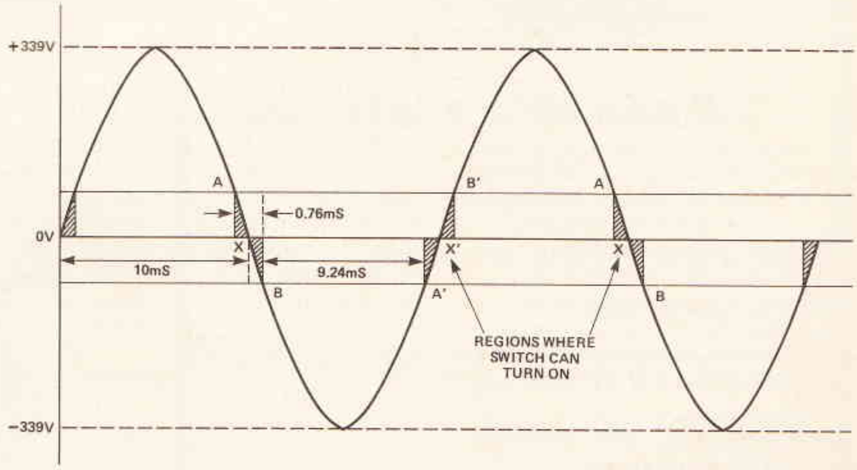
Looking at Fig. 1, we can see the effects of this. In the worst case, the light switch might close at or just before point B or B', with the result that the filament will have 80 volts applied to it immediately, and the voltage will then rise steadily to the peak voltage of 339 volts; this worst-case example is rather better than the normal possible worst case of the filament having 339 volts applied to it when it is cold.

However, most of the time, the switch-on will occur somewhere between B and A' or B' and A, with the result that no current will flow until A' or A. The lamp will then be subject to an extra warm-up period of A' to X' or A to X before commencing the first full half-cycle at zero volts.

Construction And Testing

Firstly, and most importantly, we must point out that this circuit deals with mains voltages and should be treated with all due respect — we want to keep our readers. In particular, it should either be mounted in a plastic box using nylon screws or in an earthed metal box. The terminals specified are not designed to take a mechanical pull from the leads, so you must arrange for the cable or flex connecting to the unit to be firmly anchored by some other means.

With regard to assembling the PCB itself, note that the centre leads of the SCRs should be cut; the metal tab should be secured to the PCB using a metal screw (M3.5 or similar size) to complete the circuit, as the tabs are joined to the SCR anodes. If you use alternative SCRs to the type specified, check the pin-out.



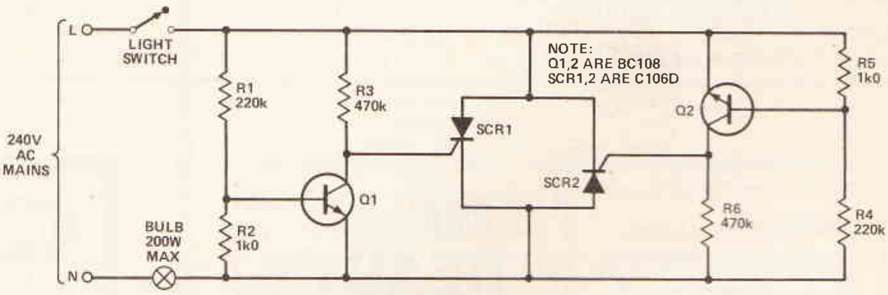


Fig. 1 (top) Switching waveforms for 'zero-crossing' switching.

Fig. 2 (above) diagram of the Lightsaver.

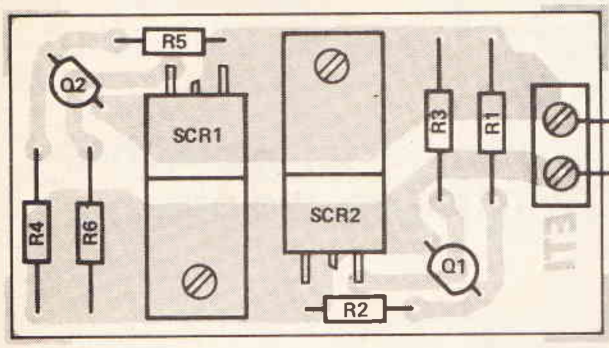
HOW IT WORKS

Up to about 80V, R1 and R2 cause there to be less than 0.4V between the base and emitter of Q1. This is too small to switch the transistor on, so the current flowing through R3 is directed to SCR1.

Above 80V or so, Q1 conducts and the gate of the thyristor is held low. This prevents it from switching on; if the lamp switch is flicked on at this moment, the circuit will wait for the mains voltage to fall again before switching the SCR on.

It was considered that the easiest way of maintaining operation during the negative half-cycle was to duplicate the circuit the other way round; hence R4-6, Q2 and SCR2.

R1 and R2 must be selected so that the voltage across R2 never exceeds the maximum V_{EBO} of the transistor, and the value of R3 must be sufficiently high for it to be able to cope with the power it will dissipate when Q1 is conducting and the resistor is effectively clamped across the mains.



PARTS LIST

RESISTORS

R1,4	220k,½W
R2,5	1k0,¼W
R3,6	470k,½W

SEMICONDUCTORS

Q1,2	BC182L
SCR1,2	C106D or similar (400V 3A)

MISCELLANEOUS

PCB; PCB mounting screw connector, two way (suitable for mains voltage); M3.5 (or similar size) short bolts & nuts; case to choice.

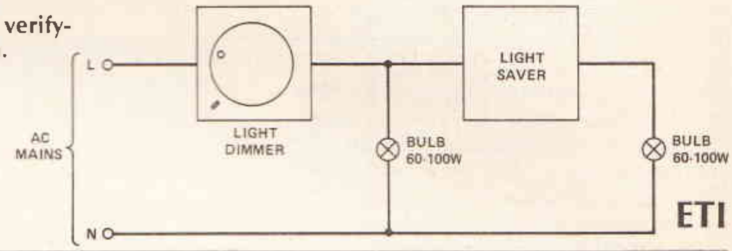
BUYLINES

If you have trouble finding any of the parts for this circuit, maybe you should take out a subscription to Hobby Electronics, or, worse, Computing Today.

If you want to check the action of the lightsaver, then you can use the circuit shown in Fig. 4, in which a dimmer is used to pick out those sections of the waveform in which the Lightsaver should be operating. The bulb attached to the Lightsaver should be on for very low and very high settings of the dimmer and should have approximately the same brightness as the other bulb (if the two wattages are the same).

Some flickering in the transition regions between on and off as the dimmer is varied is normal, and is due to (inevitable) discrepancies in the turn-on point for the two polarities of the mains waveform. With some dimmers the bulb controlled by the Lightsaver may not come on for one of either the low or high settings (possibly even both), and this will probably be due to a rather limited range of phase-angle being available from the dimmer.

Fig. 4 Method of verifying circuit action.



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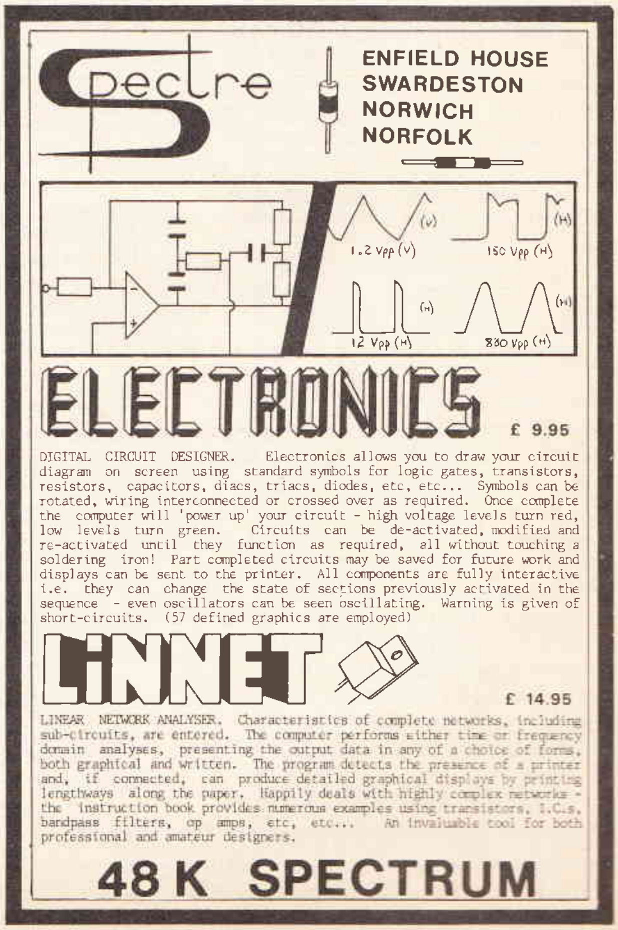

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- Be brief and to the point in your enquiries. Much as we enjoy reading your opinions on world affairs, the state of the electronics industry, and so on, it doesn't help our already overloaded enquiries service to have to plough through several pages to find exactly what information you want.

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Write For ETI

We are always looking for new contributors to the magazine, and we pay a competitive page rate. If you have built a project or you would like to write a feature on a topic that would interest ETI readers, let us have a description of your proposal, and we'll get back to you to say whether or not we're interested and give you all the boring details. (Don't forget to give us your telehone number).

We don't bother with the bureaucracy for Tech Tips — all you do is to send in your idea, stating clearly if you want an acknowledgement of receipt. If possible, please *type* your explanation of why the circuit is different, what it does and how it works, on a separate sheet from the circuit diagram; both sheets should carry your name, address and the circuit title. We'll let you know (within a month or so) if we want to use your Tech Tip.

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OOPS!

We have in the past published small corrections to projects on the letters page, and major corrections separately. From now on corrections will appear on this page, and will be repeated for several months (just to increase our embarrassment). If a correction is too large to fit on here, we will publish it just once, but will note the fact that a correction does exist, and that copies of it can be obtained from us provided you send in an SAE. But please — request copies only if you really do need them; if this service is abused, we may be forced to withdraw it.

Programmable Power Supply (January 1983)
Lascar Electronics have now moved to Module House, White Parish, Salisbury, Wiltshire SP5 2SJ.

Flash Sequencer (July '83)
Q1 should be BC184L; Q2-5 should be BC182L.

Telescope (August 1983)
We had a shower of annotation falling off our diagrams! On Fig. 1, C19 (below IC14) was not labelled nor was Q2 (above R11), and there were two C23s — one should be IC22 and it doesn't matter which. In Fig. 5, IC12 was not labelled. Unfortunately, there was a mistake in the correction (blush!): C14 is the 22μ tant on the −5 V line.

Graphic Equaliser (August 1983)
D2 and D3 are shown the wrong way round in the power supply circuit diagram on page 20.

Universal EPROM Programmer (August 1983)
Quite a few sillies here! On the circuit diagram (page 46), C6 is 100u and C9 is 100n, not the other way round as given. Some bars were omitted from note three of Table 1 on page 48: it should have read "$\overline{CE}$/PGM (27 series) is equivalent to PD/PGM (not PD/$\overline{PGM}$) (25 series)." The penultimate sentence of the first paragraph on page 50 should read ". . . adjust RV1 for a potential of +25 V at *IC10* output." On the overlay, IC7 is between SK2 and SK1, IC6 is between SK1 and C10, IC11 is between R7 and R10, R3 is between R2 and Q2, and Q7 is between Q6 and Q8. A link is missing between IC7 and SK1, and the unidentified pins at the right hand end of SK3 are the +5V line. Finally, C10 appears twice in the parts list but only the first entry is correct, and the second DIL socket should, of course, be 8, not 80, way.

Z80 Controller Computer (August 1983)
On the overlay, SW1 is the rectangle beside ICs 5 and 6, C6 should be shown between ICs 3 and 7, and a link through has been missed — to the right of pin 18, IC11.

Typewriter Interface (October 1983)
There are two errors in Table 1 on page 24: location 3C should contain E7 and location 3F should contain 5F.

Car Alarm (October 1983)
In the semiconductors section of the parts list, Q1, 2, 5, and 7 should be BC212L, Q3 should be BC182L, and Q4, 6 should be TIP31 or BD131. There was also another (inconsequential) silly but we bet you've already spotted that one!

Tech Tips (October 1983)
Ramped Pulse Generator For Stepper Motors — pin 1 of IC2 should be grounded, the Ramp Up and Ramp Down inputs accept negative, not positive, going pulses, and IC7 should be a 4011 rather than a 4001.

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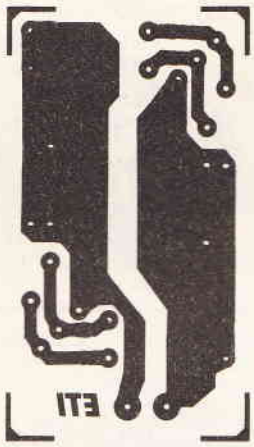
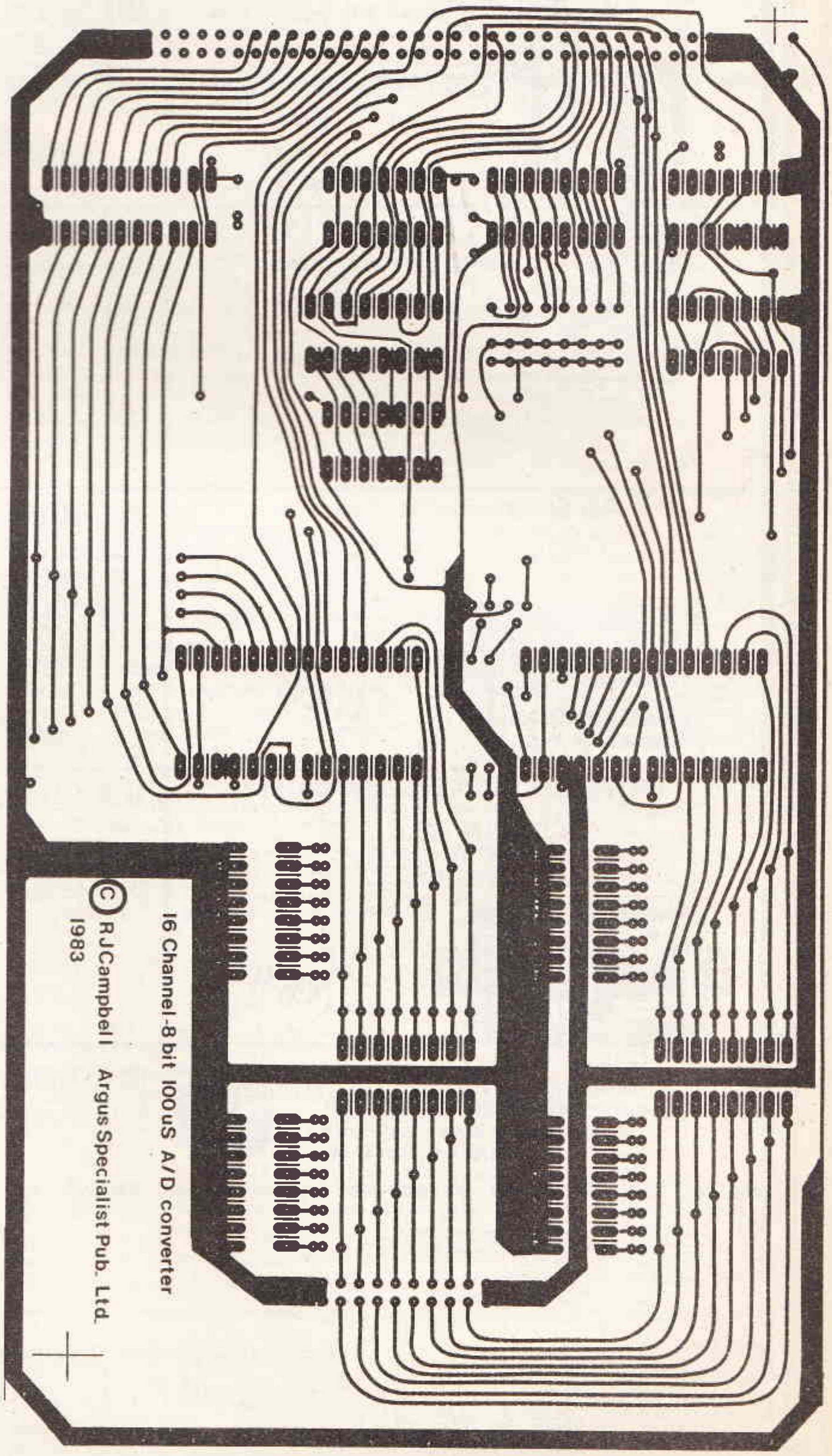
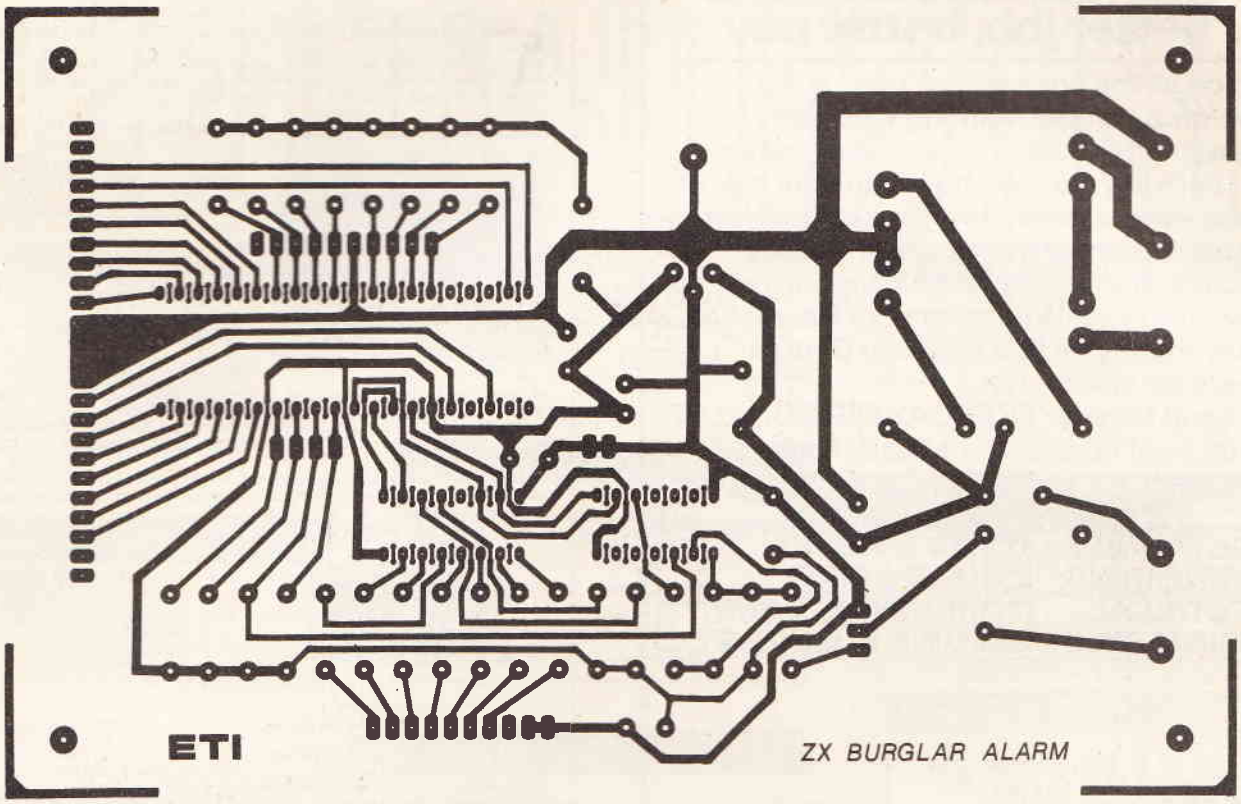


The Lightsaver

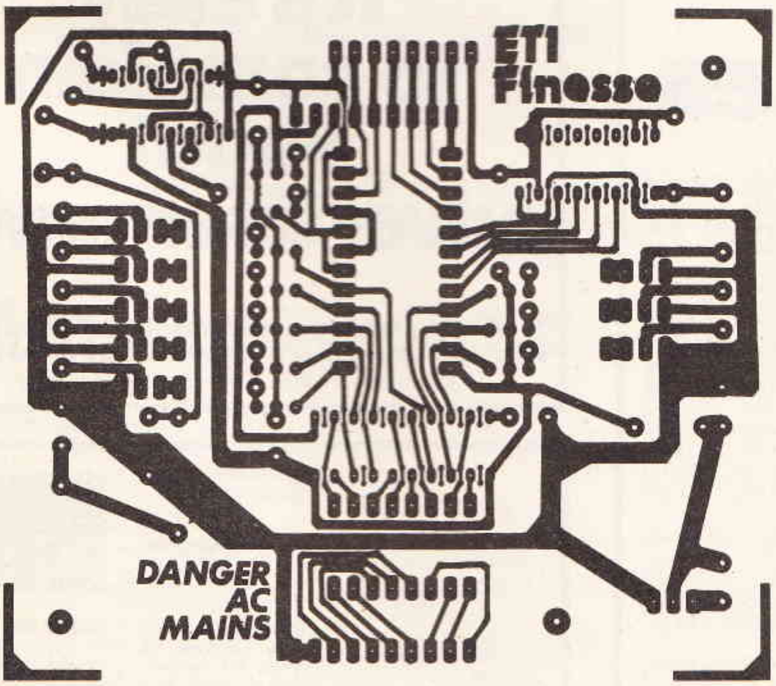


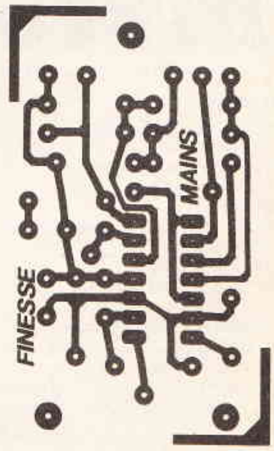
16 Channel A to D Board

Note that we have reproduced here only the underside pattern of the double sided board. The upper side pattern consists only of links, and it should be possible to produce this from reference to the overlay diagram, Fig. 3 on page 21. At a pinch, you could even use fine wire links as shown in the picture of our prototype on the cover. Just to keep everyone happy though, we will try and find space for the other foil pattern in a future issue.



ZX Burglar Alarm





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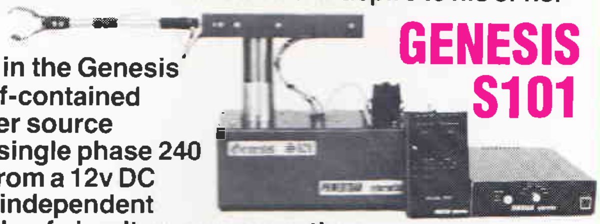

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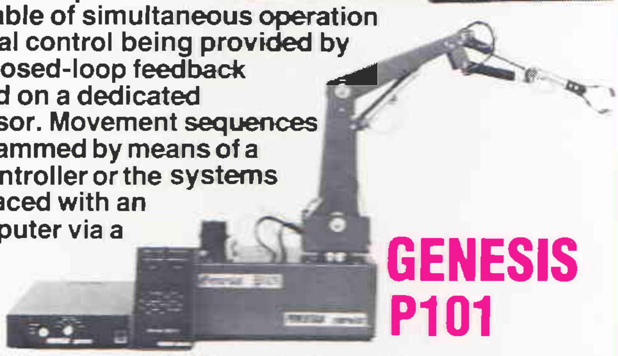

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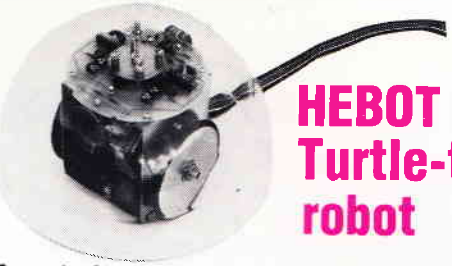

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